JAPAN

EDICT OF GOVERNMENT

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JIS B 9960-1 (2008) (English): Safety of machinery -- Electrical equipment of machines -- Part 1: General requirements

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The citizens of a nation must honor the laws of the land.

Fukuzawa Yukichi

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INDUSTRIAL
STANDARD

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JIS B 9960-1 : 2008

(JMF)

Safety of machinery—Electrical equipment of machines—Part 1: General requirements

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In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

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Contents

Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Health, Labour and Welfare and the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by the Japan Machinery Federation (JMF) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS B 9960-1** : 1999 is replaced with this Standard.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Ministers and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

JIS B 9960 consists of the following parts under the general title "*Safety of machinery—Electrical equipment of machines*":

Part 1: General requirements

Part 11: Requirements for HV equipment for voltages above 1000V a.c. or 1500V d.c. and not exceeding 36kV

Part 31: Particular safety and EMC requirements for sewing machines, units and systems

Part 32: Requirements for hoisting machines

Safety of machinery— Electrical equipment of machines— Part 1: General requirements

Introduction

This Japanese Industrial Standard has been prepared based on the fifth edition of **IEC 60204-1** published in 2005 with some modifications of the technical contents.

The portions given sidelines or dotted underlines and Annex JA to Annex JI are the matters not given in the corresponding International Standard. A list of modifications with the explanations is given in Annex JI.

The guidance on the application of this Standard is given in Annex F.

Figure 1 has been provided as an aid to the understanding of the inter-relationship of the various elements of a machine and its associated equipment. Figure 1 is a block diagram of a typical machine and associated equipment showing the various elements of the electrical equipment addressed in this Standard. Numbers in parentheses refer to clauses and subclauses in this Standard. It is understood in figure 1 that all of the elements including the safeguards, accessory tool/fixture, software and the documentation taken together constitute the machine, and that one or more machines working together with usually at least one level of supervisory control constitute a manufacturing cell or a manufacturing system.

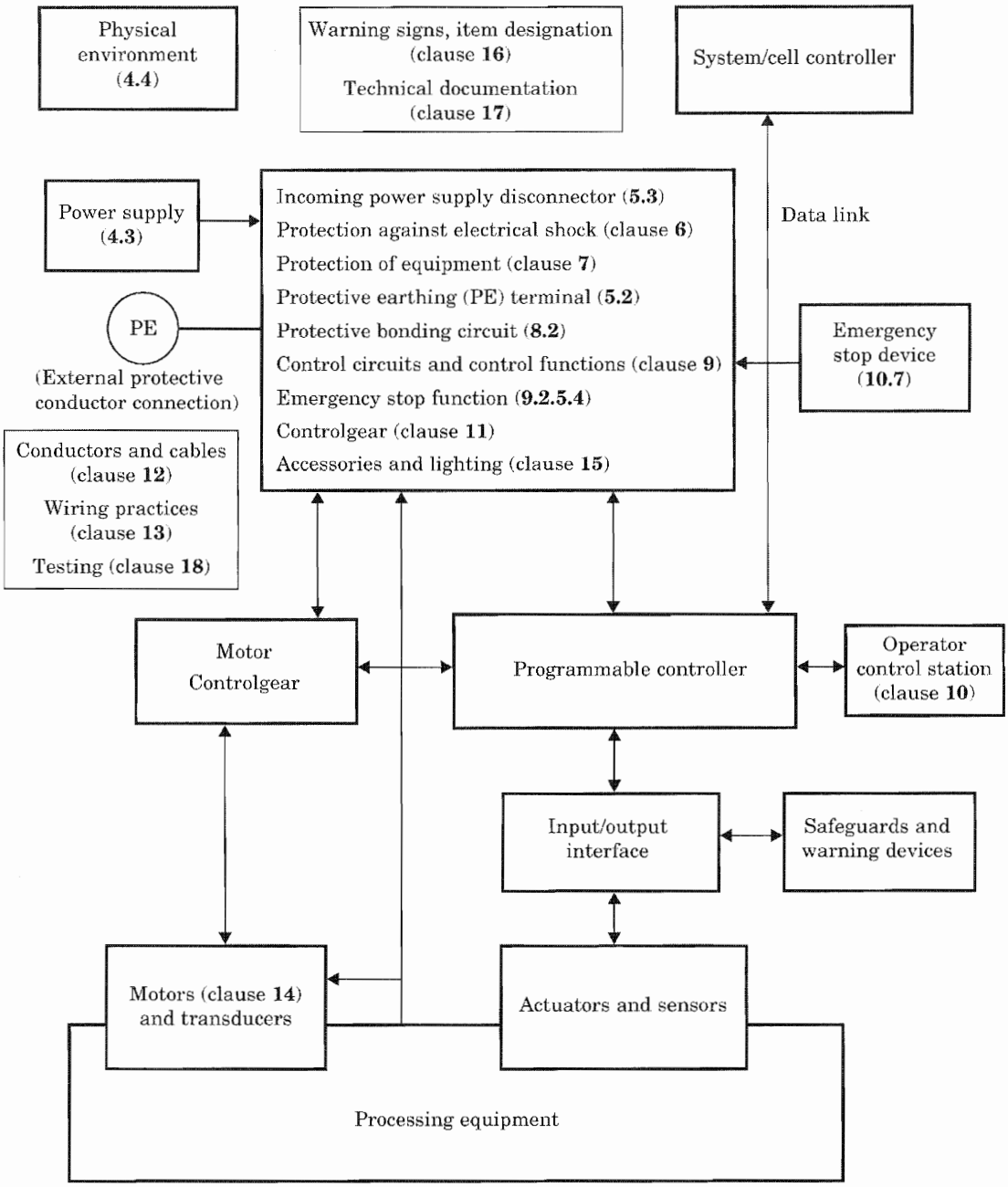


Figure 1 Block diagram of typical machine

1 Scope

This Standard specifies the requirements and recommendations to achieve the following matters relating to the electrical equipment of machines.

— Safety of persons and property

— Consistency of control response

— Ease of maintenance

This Standard applies to the electrical, electronic and programmable electronic equipment and systems to machines not portable by hand while working including a group of machines working together in a co-ordinated manner.

NOTE 1 This Standard is an application standard for technology and is not intended to limit or inhibit technological advancement.

NOTE 2 In this Standard, the term "electrical" includes electrical, electronic and programmable electronic matters (i.e. the electrical equipment includes electrical, electronic and programmable electronic equipment).

NOTE 3 In this Standard, the term "person" refers to any individual and includes those persons who are assigned and instructed by the user or his agent(s) in the use and care of the machine in question.

The equipment covered by this Standard commences at the connecting point of the power supply to the electrical equipment of the machine (see **5.1**).

NOTE 4 The requirements for the power supply facility in buildings are specified in **JIS C 60364** series.

This Standard is applicable to the electrical equipment that operates with nominal power supply voltage of 1 000 V or under for alternate current (a.c.) and of 1 500 V or under for direct current (d.c.) and with nominal frequencies of 200 Hz or under.

NOTE 5 For higher voltages, requirements are specified in **JIS B 9960-11**.

This Standard does not cover all the requirements (for example, guarding, interlocking or control) that are needed or required by other standards or regulations in order to protect persons from hazards other than electrical hazards. Each type of machine has unique requirements to be accommodated to provide adequate safety.

The scope of this Standard specifically includes the electrical equipment of machines as defined in **3.35**, but is not limited to.

NOTE 6 Annex C lists examples of machines using the electrical equipment to which this Standard is applicable.

This Standard does not specify additional and special requirements that can apply to the electrical equipment of machines exemplified as follows.

— That are intended for use in open air (i.e. outside building or other protective structures)

— That use, process, or produce potentially explosive material (for example, paint or swarf)

— That are intended for use in potentially explosive or flammable atmosphere

— That have special risks when producing or using certain materials

— That are intended for use in mines

— Sewing machines, units and systems (specified in **JIS B 9960-31**)

— Hoisting machines (specified in **JIS B 9960-32**)

Power circuits where electrical energy is directly used as a working tool are excluded from this Standard.

NOTE 7 The International Standard corresponding to this Standard is as follows.

IEC 60204-1 : 2005 *Safety of machinery—Electrical equipment of machines—Part 1: General requirements* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For standards with the year indication, only the editions of the indicated year shall apply but the revisions (including amendments) made thereafter shall not apply. The normative reference without the indication of the year shall apply only to the most recent edition (including amendments).

JIS B 9700-1 : 2004 *Safety of machinery—Basic concepts, general principles for design—Part 1: Basic terminology, methodology*

NOTE : Corresponding International Standard: ISO 12100-1 : 2003 *Safety of machinery—Basic concepts, general principles for design—Part 1: Basic terminology, methodology* (IDT)

JIS B 9700-2 : 2004 *Safety of machinery—Basic concepts, general principles for design—Part 2: Technical principles*

NOTE : Corresponding International Standard: ISO 12100-2 : 2003 *Safety of machinery—Basic concepts, general principles for design—Part 2: Technical principles* (IDT)

JIS B 9703 : 2000 *Safety of machinery—Emergency stop—Principles for design*

NOTE : Corresponding International Standard: ISO 13850 : 1996 *Safety of machinery—Emergency stop—Principles for design* (IDT)

JIS B 9705-1 : 2000 *Safety of machinery—Safety-related parts of control systems—Part 1: General principles for design*

NOTE : Corresponding International Standard: ISO 13849-1 : 1999 *Safety of machinery—Safety-related parts of control systems—Part 1: General principles for design* (IDT)

JIS B 9706-1 : 2001 *Safety of machinery—Indication, marking and actuation—Part 1: Requirements for visual, auditory and tactile signals*

NOTE : Corresponding International Standard: IEC 61310-1 : 1995 *Safety of machinery—Indication, marking and actuation—Part 1: Requirements for visual, auditory and tactile signals* (IDT)

JIS B 9706-2 : 2001 *Safety of machinery—Indication, marking and actuation—Part 2: Requirements for marking*

NOTE : Corresponding International Standard: IEC 61310-2 : 1995 *Safety of machinery—Indication, marking and actuation—Part 2: Requirements for marking* (IDT)

JIS B 9706-3 : 2001 *Safety of machinery—Indication, marking and actuation—Part 3: Requirements for the location and operation of actuators*

NOTE : Corresponding International Standard: IEC 61310-3 : 1999 *Safety of machinery—Indication, marking and actuation—Part 3: Requirements for the location and operation of actuators* (IDT)

JIS B 9961 : 2008 *Safety of machinery—Functional safety of safety-related electrical, electronic and programmable electronic control systems*

NOTE : Corresponding International Standard: IEC 62061 : 2005 *Safety of machinery—Functional safety of safety-related electrical, electronic and programmable electronic control systems* (IDT)

JIS C 0365 *Protection against electric shock—Common aspects for installation and equipment*

NOTE : Corresponding International Standard: IEC 61140 *Protection against electric shock—Common aspects for installation and equipment* (IDT)

JIS C 0445 *Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system*

NOTE : Corresponding International Standard: IEC 60445 *Basic and safety principles for man-machine interface, marking and identification—Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system* (IDT)

JIS C 0447 *Man-machine interface (MMI)—Actuating principles*

NOTE : Corresponding International Standard: IEC 60447 *Man-machine interface (MMI)—Actuating principles* (IDT)

JIS C 0448 *Coding of indicating devices and actuators by colours and supplementary means*

NOTE : Corresponding International Standard: IEC 60073 *Basic and safety principles for man-machine interface, marking and identification—Coding principles for indication devices and actuators* (IDT)

JIS C 0452-1 : 2004 *Industrial system, installations and equipment and industrial products—Structuring principles and reference designations—Part 1: Basic rules*

NOTE : Corresponding International Standard: IEC 61346-1 : 1996 *Industrial systems, installations and equipment and industrial products—Structuring principles and reference designations—Part 1: Basic rules* (IDT)

JIS C 0452-2 : 2005 *Industrial systems, installations and equipment and industrial products—Structuring principles and reference designations—Part 2: Classification of objects and codes for classes*

NOTE : Corresponding International Standard: IEC 61346-2 : 2000 *Industrial systems, installations and equipment and industrial products—Structuring principles and reference designations—Part 2: Classification of objects and codes for classes* (IDT)

JIS C 0453 : 2005 *Preparation of parts lists*

NOTE : Corresponding International Standard: IEC 62027 : 2000 *Preparation of parts lists* (IDT)

JIS C 0457 : 2006 *Preparation of instructions—Structuring, content and presentation*

NOTE : Corresponding International Standard: IEC 62079 : 2001 *Preparation of instructions—Structuring, content and presentation* (IDT)

JIS C 0617 (series) *Graphical symbols for diagrams*

NOTE : Corresponding International Standard: IEC 60617 (series) *Graphical symbols for diagrams* (IDT)

JIS C 0664 : 2003 *Insulation coordination for low-voltage equipment Part 1: Principles, requirements and tests*

NOTE : Corresponding International Standard: IEC 60664-1 : 1992 *Insulation coordination for equipment within low-voltage systems—Part 1: Principles, requirements and tests* (MOD)

JIS C 0920 : 2003 *Degrees of protection provided by enclosures (IP Code)*

NOTE : Corresponding International Standard: IEC 60529 : 2001 *Degrees of protection provided by enclosures (IP Code)* (IDT)

JIS C 1082-1 : 1999 *Preparation of documents used in electrotechnology—Part 1: General requirements*

NOTE : Corresponding International Standard: IEC 61082-1 : 1991 *Preparation of documents used in electrotechnology—Part 1: General requirements* (including Amendment 1 and Amendment 2) (MOD)

JIS C 1082-2 : 1999 *Preparation of documents used in electrotechnology—Part 2: Function-oriented diagrams*

NOTE : Corresponding International Standard: IEC 61082-2 : 1993 *Preparation of documents used in electrotechnology—Part 2: Function-oriented diagrams* (IDT)

JIS C 1082-3 : 1999 *Preparation of documents used in electrotechnology—Part 3: Connection diagrams, tables and lists*

NOTE : Corresponding International Standard: IEC 61082-3 : 1993 *Preparation of documents used in electrotechnology—Part 3: Connection diagrams, tables and lists* (IDT)

JIS C 1082-4 : 1999 *Preparation of documents used in electrotechnology—Part 4: Location and installation documents*

NOTE : Corresponding International Standard: IEC 61082-4 : 1996 *Preparation of documents used in electrotechnology—Part 4: Location and installation documents* (IDT)

JIS C 2811 *Terminal blocks for industrial and similar use*

NOTE : Corresponding International Standard: IEC 60947-7-1 : 1989 *Low-voltage switchgear and controlgear—Part 7-1: Ancillary equipment—Terminal blocks for copper conductors* (MOD)

JIS C 4034-1 *Rotating electrical machines Part 1: Rating and performance*

NOTE : Corresponding International Standard: IEC 60034-1 *Rotating electrical machines—Part 1: Rating and performance* (NEQ)

JIS C 4034-5 *Rotating electrical machines—Part 5: Classification of degrees of protection provided by enclosures of rotating electrical machines (IP code)*

NOTE : Corresponding International Standard: IEC 60034-5 *Rotating electrical machines—Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code)—Classification* (IDT)

JIS C 4203 : 2001 *Single phase induction motors for general purpose*

NOTE : Corresponding International Standards:

IEC 60072-1 : 1991 *Dimensions and output series for rotating electrical machines—Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080* (MOD)

IEC 60034-1 : 1996 *Rotating electrical machines—Part 1: Rating and performance* (MOD)

JIS C 4210 : 2001 *Low-voltage three-phase squirrel-cage induction motors for general purpose*

NOTE : Corresponding International Standards:

IEC 60072-1 : 1991 *Dimensions and output series for rotating electrical machines—Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080* (MOD)

IEC 60034-1 : 1996 *Rotating electrical machines—Part 1: Rating and performance* (MOD)

IEC 60034-2 : 1972 *Rotating electrical machines—Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests* (MOD)

IEC 60034-9 : 1997 *Rotating electrical machines—Part 9: Noise limits* (MOD)

IEC 60034-12 : 1972 *Rotating electrical machines—Part 12: Starting performance of single-speed three-phase cage induction motors for voltage up to and including 660 V* (MOD)

JIS C 4212 : 2000 *Low-voltage three-phase squirrel-cage high efficiency induction motors*

NOTE : Corresponding International Standard: IEC 60072-1 : 1991 *Dimensions and output series for rotating electrical machines—Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080* (MOD)

JIS C 60364-4-41 : 2006 *Electrical installations of buildings—Part 4-41: Protection for safety—Protection against electric shock*

NOTE : Corresponding International Standard: IEC 60364-4-41 : 2001 *Electrical installations of buildings—Part 4-41: Protection for safety—Protection against electric shock* (IDT)

JIS C 60364-4-43 : 2006 *Electrical installations of buildings—Part 4-43: Protection for safety—Protection against overcurrent*

NOTE : Corresponding International Standard: IEC 60364-4-43 : 2001 *Electrical installations of buildings—Part 4-43: Protection for safety—Protection against overcurrent* (IDT)

JIS C 60364-5-52 : 2006 *Electrical installations of buildings—Part 5-52: Selection and erection of electrical equipment—Wiring systems*

NOTE : Corresponding International Standard: IEC 60364-5-52 : 2001 *Electrical installations of buildings—Part 5-52: Selection and erection of electrical equipment—Wiring systems* (IDT)

JIS C 60364-5-53 : 2006 *Electrical installations of buildings—Part 5-53: Selection and erection of electrical equipment—Isolation, switching and control*

NOTE : Corresponding International Standard: IEC 60364-5-53 : 2001 *Electrical installations of buildings—Part 5-53: Selection and erection of electrical equipment-Isolation, switching and control* (IDT)

JIS C 60364-5-54 : 2006 *Electrical installations of buildings—Part 5-54: Selection and erection of electrical equipment—Earthing arrangements, protective conductors and protective bonding conductors*

NOTE : Corresponding International Standard: IEC 60364-5-54 : 2002 *Electrical installations of buildings—Part 5-54: Selection and erection of electrical equipment—Earthing arrangements, protective conductors and protective bonding conductors* (IDT)

JIS C 60364-6-61 : 2006 *Electrical installations of buildings—Part 6-61: Verification—Initial verification*

NOTE : Corresponding International Standard: IEC 60364-6-61 : 2001 *Electrical installations of buildings—Part 6-61: Verification—Initial verification* (IDT)

JIS C 8201-1 *Low-voltage switchgear and controlgear—Part 1: General rules*

NOTE : Corresponding International Standard: IEC 60947-1 *Low-voltage switchgear and controlgear—Part 1: General rules* (MOD)

JIS C 8201-2-1 : 2004 *Low-voltage switchgear and controlgear—Part 2-1: Circuit-breakers*

NOTE : Corresponding International Standard: IEC 60947-2 : 2003 *Low-voltage switchgear and controlgear—Part 2: Circuit-breakers* (MOD)

JIS C 8201-2-2 : 2004 *Low-voltage switchgear and controlgear—Part 2-2: Circuit-breakers incorporating residual current protection*

NOTE : Corresponding International Standard: IEC 60947-2 : 2003 *Low-voltage switchgear and controlgear—Part 2: Circuit-breakers (Annex B)* (MOD)

JIS C 8201-3 *Low-voltage switchgear and controlgear—Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

NOTE : Corresponding International Standard: IEC 60947-3 *Low-voltage switchgear and controlgear—Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units* (MOD)

JIS C 8201-5-1 *Low-voltage switchgear and controlgear—Part 5-1: Control circuit devices and switching elements—Electromechanical control circuit devices*

NOTE : Corresponding International Standard: IEC 60947-5-1 *Low-voltage switchgear and controlgear—Part 5-1: Control circuit devices and switching elements—Electromechanical control circuit devices* (MOD)

JIS C 8285-1 *Plugs, socket-outlets and couplers for industrial purposes—Part 1: General requirements*

NOTE : Corresponding International Standard: IEC 60309-1 *Plugs, socket-outlets, and couplers for industrial purposes—Part 1: General requirements* (MOD)

ISO 7000 : 2004 *Graphical symbols for use on equipment—Index and synopsis*

ISO 13849-2 : 2003 *Safety of machinery—Safety-related parts of control systems—Part 2: Validation*

IEC 60034-11 *Rotating electrical machines—Part 11: Thermal protection*

IEC 60072-2 : 1990 *Dimensions and output series for rotating electrical machines—Part 2: Frame numbers 355 to 1000 and flange numbers 1180 to 2360*

IEC 60417-DB : 2002 *Graphical symbols for use on equipment*

IEC 60439-1 : 1999 *Low-voltage switchgear and controlgear assemblies—Part 1: Type-tested and partially type-tested assemblies*

IEC 60445 : 1999 *Basic and safety principles for man-machine interface, marking and identification—Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system*

IEC 60446 : 1999 *Basic and safety principles for man-machine interface, marking and identification—Identification of conductors by colours or numerals*

IEC 60898 : 1995 *Electrical accesories—Circuit-breakers for overcurrent protection for household and similar installations*

IEC 60621-3 : 1979 *Electrical installations for outdoor sites under heavy conditions (including open-cast mines and quarries). Part 3: General requirements for equipment and ancillaries*

IEC 60947-3 : 1999 *Low-voltage switchgear and controlgear—Part 3: Switches, disconnectors, switch-disconnectors, and fuse combination units*

IEC 61557-3 : 1997 *Electrical safety in low voltage distribution systems up to 1000 V a.c. and 1500 V d.c.—Equipment for testing, measuring or monitoring of protective measures—Part 3: Loop impedance*

IEC 61558-1 : 1997 *Safety of power transformers, power supply units and similar—Part 1: General requirements and tests*, Amendment 1 (1998)

IEC 61558-2-6 *Safety of power transformers, power supply units and similar—Part 2-6: Particular requirements for safety isolating transformers for general use*

IEC 61984 : 2001 *Connectors—Safety requirements and tests*

IEC 62023 : 2000 *Structuring of technical information and documentation*

3 Terms and definitions

For the purposes of this Standard, the following terms and definitions shall apply.

3.1 actuator

part of a device to which an external manual operation is to be applied

NOTE 1 The actuator may take the form of a handle, knob, push-button, roller, plunger, etc.

NOTE 2 Some actuating means do not require an external actuating force but only an action of region of body (hand, foot, etc.).

NOTE 3 See also **3.34**.

3.2 ambient temperature

temperature of the air or other medium where the equipment is to be used

3.3 barrier

part providing protection against direct contact from any usual direction of access (according to **IEV 826-03-13**) [1)]

Note [1)] IEV: International Electrotechnical Vocabulary is specified in **IEC 60050**, and **IEV 826-03-13** is corresponding to **IEC 60050-826-03-13** (hereafter, in the same manner).

3.4 cable tray

cable support consisting of a continuous base and raised edges and no covering (according to **IEV 826-15-08**).

NOTE : A cable tray may be perforated or non-perforated.

3.5 cable trunking system

system of closed enclosures comprising a base with a removable cover intended for the complete surrounding of insulated conductors, cables, cords and for the accommodation of other electrical equipment

3.6 concurrent actuation

actuation performed concurrently

It is used to describe a situation wherein two or more control devices are actuated at the same time (but not necessarily synchronously).

3.7 conduit

closed wiring part of circular or non-circular cross-section for insulated conductors or cables in electrical installations allowing them to be drawn in and/or replaced (according to **IEV 826-06-03**)

NOTE : Conduits should be sufficiently close-jointed so that the insulated conductors or cables can only be drawn in and not inserted laterally.

3.8 control circuit (of a machine)
circuit used for controlling (including monitoring) the machine and the electrical equipment

3.9 control device
device connected into the control circuit and used for controlling the machine operation (for example, position sensor, manual operating switch, relay, contactor, magnetically operated valve)

3.10 controlgear
switching devices and their combination with associated control, measuring, protective, and regulating equipment, and also assemblies of such devices and equipment associated with interconnections, accessories, enclosures and supporting structures, intended in principle for the control of electrical energy consuming equipment (**IEV 441-11-03** is modified)

3.11 controlled stop
stopping of machine with power supply to the machine actuators maintained during the stopping process

3.12 direct contact
contact of persons or livestock with live parts (according to **IEV 826-12-03**)

3.13 direct opening action (of a contact element)
achievement of contact separation as the direct result of a specified movement of the switch actuator through non-resilient members (for example, not dependent upon springs) (according to **K.2.2** of **JIS C 8201-5-1**)

3.14 duct
enclosed channel designed for holding or protecting electrical conductors, cables, and busbars

NOTE : Conduits (see **3.7**), cable trunking systems (see **3.5**) and underfloor channels are types of duct.

3.15 electrical operating area
room or location for electrical equipment to which access is intended to be restricted to instructed or skilled persons by the opening of a door or the removal of a barrier without the use of a key or tool, and which is clearly marked by appropriate warning signs

3.16 electronic equipment
part of the electrical equipment containing circuitry dependent for its operation on electronic devices and components

3.17 emergency stop device
control device manually actuates an emergency stop function (according to **3.2** of **JIS B 9703**)

NOTE : See Annex E.

3.18 emergency switching off device

control device manually breaks the supply of electrical energy to all or a part of an installation where a risk of electric shock or another risk of electrical origin is involved

NOTE : See Annex E.

3.19 enclosed electrical operating area

room or location for electrical equipment to which access is intended to be restricted to instructed or skilled persons by the opening of a door or the removal of a barrier with the use of a key or tool, and which is clearly marked by appropriate warning signs

3.20 enclosure

part providing protection of electrical equipment against certain external influences and protection against direct contact from any direction

NOTE : The following explanations are added so that the definition taken from the existing **IEV** is applicable to this Standard.

a) Enclosures provide protection of persons or livestock against access to hazardous parts.

b) Barriers, shaped openings or any other means suitable to prevent or limit the penetration of the specified test probes, whether attached to the enclosure or formed by the enclosed equipment, are considered as part of the enclosure except for those removable without the use of a key or tool.

c) The following shall also be regarded as the enclosure.

— A cabinet or box, either mounted on the machine or separated from the machine

— A compartment consisting of an enclosed space within the machine structure (see **13.5.7**).

3.21 equipment

material, fixtures, devices, components, parts, apparatus and the like used as a part of or in connection with the electrical equipment of machines

3.22 equipotential bonding

provision of electric connections between conductive parts intended to achieve equipotentiality (according to **IEV 195-1-10**)

3.23 exposed conductive part

touchable conductive part of electrical equipment which is not live under normal operating conditions, but can become live under fault conditions (insulation failure) (**IEV 826-12-10** is modified)

3.24 extraneous conductive part

conductive part not forming the electrical installation and liable to introduce a potential, generally the earth potential (**IEV 826-12-11** is modified)

3.25 failure

termination of the ability of an item [2)] to perform a required function

Note [2] An item means the generic term of, or any one of, a part, component, device, equipment, functional unit, instrument, subsystem and system targeted for the dependability. The item consists of hardware, software or both of them.

NOTE 1 After failure, the item has a fault (state).

NOTE 2 "Failure" is an event, as distinguished from "fault" which is a state.

NOTE 3 This concept as defined does not apply to the items consisting of software only (according to **IEV 191-04-01**).

NOTE 4 In practice, the terms "fault" and "failure" are often used synonymously.

3.26 fault

state of an item characterized by inability to perform a required function excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources

NOTE 1 A fault is often the result of a failure of the item itself, but may exist without prior failure.

NOTE 2 In English, the term "fault" may mean the insulation failure or the ground fault. In **IEC 60204-1**, "fault" is often used in this meaning.

3.27 functional bonding

equipotential bonding necessary for proper functioning of electrical equipment

3.28 hazard

potential source of physical injury or damage to health

NOTE 1 The term "hazard " may be qualified in order to define its origin (for example, mechanical hazard, electrical hazard) or the nature of the potential harm (for example, electric shock hazard, cutting hazard, toxic hazard, fire hazard).

NOTE 2 In this definition, the following is envisaged as hazards.

— That permanently present during the "intended use" of the machine (for example, motion of hazardous moving elements, electric arc during a welding phase, unhealthy posture, noise emission, high temperature)

— That can appear unexpectedly (for example, explosion, crushing hazard as a consequence of an unintended/unexpected start-up, ejection as a consequence of a breakage, fail as a consequence of acceleration/deceleration).

(**3.6** of **JIS B 9700-1** is modified)

3.29 indirect contact

contact of persons or livestock with exposed conductive parts which have become live under insulation failure (according to **IEV 826-12-04**)

3.30 inductive power supply system

system of inductive power supply consisting of a track converter and a track conductor along which one or more pick-ups and associated pick-up converter can move and

capable of feeding without any electric or mechanical contact, for example, to a mobile machine

NOTE : The track conductor and the pick-up are analogous to the primary winding and secondary winding of a transformer, respectively.

3.31 (electrically) instructed person

person adequately advised or supervised by an electrically skilled person to enable him or her to perceive risks and to avoid hazards which electricity can create (**IEV 826-18-02** is modified)

3.32 interlock (for safeguarding)

arrangement that interconnects guard(s) or device(s) with the control system and/or all or part of the power supply to the machine

3.33 live part

conductor or conductive part intended to be energized in normal use, including a neutral conductor but usually not a PEN conductor

NOTE : This term does not necessarily imply the conductor having a risk of electric shock.

3.34 machine actuator

driving mechanism used to actuate the machine

3.35 machinery, machine

combination of linked parts or components at least one of which moves with the appropriate machine actuators, control and power circuits, joined together for a specific application, in particular for the processing, treatment, moving or packaging of material

The term "machinery" also covers an assembly of machines which, in order to achieve the same purpose, are arranged and controlled so that they function as an integral whole (**3.1** of **JIS B 9700-1** is modified).

NOTE : The term "component" is used here in a general sense and it does not refer only to electrical components.

3.36 marking

signs or inscriptions primarily for the purpose of identifying equipment, components and/or devices (including certain features thereof)

3.37 neutral conductor, N

conductor connected to the neutral point of a power supply system and capable of contributing to the transmission of electrical energy (**IEV 826-14-07** is modified)

3.38 obstacle

structure preventing unintentional direct contact but not preventing direct contact by deliberate action

3.39 overcurrent

current exceeding the rated value

The rated value of conductor refers to the permissible current-carrying capacity (**IEV 826-11-14** is modified)

3.40 overload (of a circuit)

amount (I^2t) related to time and current in a circuit which is in excess of the rated load of the circuit when the circuit is not under a fault condition

NOTE : Overload should not be used as a synonym for overcurrent.

3.41 plug/socket combination

component and a suitable mating component, appropriate to terminate conductors, intended for connection or disconnection of two or more conductors

NOTE : Examples of plug/socket combination are as follows.

— Connectors satisfying the requirements of **IEC 61984**

— A plug and socket-outlet, a cable coupler or an appliance coupler in accordance with **JIS C 8285-1**

— A plug and socket-outlet in accordance with **IEC 60884-1** or an appliance coupler (power supply connector) in accordance with **IEC 60320-1**

3.42 power circuit

circuit that supplies power from the power supply network to each part of equipment for production and to transformers for control

3.43 protective bonding

equipotential bonding for protection against electric shock

NOTE : Measures for protection against electric shock can also reduce the risk of burns or fire.

3.44 protective bonding circuit

protective conductors and conductive parts connected together to provide protection against electric shock in the event of an insulation failure (residual current)

3.45 protective conductor

conductor required for protective bonding by some measures for protection against electric shock for electrically connecting any of the following parts

— exposed conductive parts

— extraneous conductive parts

— main earthing terminal (PE)

(**IEV 826-13-22** is modified)

3.46 redundancy

application of more than one device or system, or part of a device or system, with the objective of ensuring that in the event of one failing to perform its function, another is available to perform that function

3.47 reference designation

symbol which serves to identify an item in the documentation and on the equipment

NOTE : The term "reference designation" used in this Standard corresponds to the term "reference designation" of **JIS C 0452-1**.

3.48 risk

combination of the probability of occurrence of harm (i.e. physical injury or damage to health) and the severity of that harm (**3.11** of **JIS B 9700-1** is modified)

3.49 safeguard

guard or protective device provided as a means to protect persons from a hazard

3.50 safeguarding

protective measure using safeguards to protect persons from the hazards which cannot reasonably be eliminated or from the risks which cannot be sufficiently reduced by inherently safe design measures (according to **3.20** of **JIS B 9700-1**)

3.51 servicing level

position (level) on which persons stand when operating or maintaining the electrical equipment

3.52 short-circuit current

overcurrent resulting from a short-circuit due to a fault or an incorrect connection in an electric circuit (according to **IEV 441-11-07**)

3.53 (electrically) skilled person

person with relevant training, education and experience to enable him or her to avoid hazards associated with electricity (**IEV 826-18-01** is modified)

3.54 supplier

entity (for example, manufacturer, contractor, installer, integrator) who provides equipment or services associated with the machine

NOTE : The user organization may also be act in the capacity of a supplier to itself.

3.55 switching device

device designed to make and/or break the current in one or more electric circuits (**IEV 441-14-01** is modified)

NOTE : A switching device may perform one or both of these functions.

3.56 uncontrolled stop

stopping of machine motion by removing electrical power to the machine actuators

NOTE : This definition does not imply any particular state of other stopping devices (for example, mechanical brake or hydraulic brakes).

3.57 user

entity (individual or group) who utilizes the machine and its associated electrical equipment

4 General requirements

4.1 General consideration

This Standard is intended to apply to electrical equipment used with a wide variety of machines and with a group of machines working together in a co-ordinated manner.

The risks associated with the hazards relevant to the electrical equipment shall be assessed as part of the overall requirements for risk assessment of the machine. This will determine the adequate risk reduction, and the necessary protective measures for persons who may be exposed to those hazards, while still maintaining an acceptable level of performance of the machine and its equipment.

Hazardous situations can result from but are not limited to, the following causes.

— Failures or faults in the electrical equipment resulting in the possibility of electric shock or electrical fire

— Failures or faults in control circuits (or components and devices thereof) resulting in the malfunctioning of the machine

— Fluctuation or loss in power supply as well as failures or faults in power circuit resulting in the malfunctioning of the machine

— Loss of continuity of contact circuits that depend upon sliding or rolling contacts, resulting in failure of safety function

— Electrical disturbance (for example, electromagnetic disturbance, electrostatic) either from outside the electrical equipment or internally generated, resulting in the malfunctioning of the machine

— Release of stored energy (either electrical or mechanical) resulting in, for example, unexpected movement that may cause electric shock or injury

— Audible noise at levels that cause health problems to persons

— Surface temperatures that may cause injury

Safety measures are a combination of the measure incorporated by the supplier of the electrical equipment at the design stage and those measures required to be implemented by the user.

The design and development process shall identify hazards and the risks arising from them. Where the hazards cannot be removed and/or the risks cannot be sufficiently reduced by inherently safe design measures, protective measures (for example, safeguarding) shall be provided to reduce the risk. Additional means (for example, awareness means) shall be provided where further risk reduction is necessary. In addition, working procedures that reduce the risk can be necessary.

The use of the enquiry form as shown in Annex B is recommended in order to facilitate an appropriate agreement between the user and the supplier on basic conditions and additional user specifications related to the electrical equipment. The purpose to designate the additional specification in the enquiry shall be as follows.

— Provide additional feature that are dependent on the type of machine (or group of machines) and the application

— Facilitate maintenance and repair

— Improve the reliability and ease of operation

4.2 Selection of equipment

4.2.1 General

Electrical components and electrical devices used for the electrical equipment of machine shall satisfy all of the following.

— Suitable for the intended use

— Conforming to relevant Japanese Industrial Standards and **IEC** Standards where such exist

— Used in accordance with the supplier's instructions

4.2.2 Electrical equipment conforming to IEC 60439 series

The electrical equipment of machine shall satisfy the safety requirements identified by the risk assessment of the machine. Depending upon the machine, its intended use and its electrical equipment, the designer may select parts of the electrical equipment of the machine that conform to **IEC 60439** series (see Annex F).

NOTE : The **IEC 60439** series specifies the requirements for equipment covering a wide range of possible applications of low-voltage switchgear and controlgear assemblies.

4.3 Power supply

4.3.1 General

The electrical equipment shall be designed to operate correctly with one of the following power supply conditions.

— That given in **4.3.2** or **4.3.3**

— That specified by the user (see Annex B)

— That specified by the supplier (in the case of a special source of power supply such as an on-board generator)

4.3.2 AC power supply

Voltage	0.9 to 1.1 of nominal voltage under steady state
Frequency	0.99 to 1.01 (continuity) or 0.98 to 1.02 (short time) of nominal frequency of power supply
Harmonics	Harmonics distortion (content) shall be 10 % or under of total r.m.s. voltage between live conductors for the sum of the second harmonic through the fifth harmonic, and 2 % or under of total r.m.s. voltage between live conductors for the sum of the sixth harmonic through the thirtieth harmonic.
Voltage unbalance	Neither the voltage of the negative sequence component nor the voltage of the zero sequence component in three-phase power supplies exceeding 2 % of the positive sequence component.

Voltage interruption	Power supply interrupted or at zero voltage for 3 ms or under at any random time in the power supply cycle with over 1 s between successive interruptions
Voltage dips	Voltage dips shall be 20 % or under of the peak voltage of power supply for one cycle or under with over 1 s between successive dips

4.3.3 DC power supply

Battery power supply

Voltage	0.85 to 1.15 of nominal voltage 0.7 to 1.2 of nominal voltage in the case of battery-operated vehicles
Voltage interruption	5 ms or under

Converter power supply

Voltage	0.9 to 1.1 of nominal voltage
Voltage interruption	20 ms or under with over 1 s between successive interruptions

NOTE : The value in **IEC Guide 106** (specified value of 500 ms) is modified to ensure proper operation of electrical equipment.

Ripple (p-p value)	0.15 or under of nominal voltage

4.3.4 Special power supply systems

For the special power supply systems such as on-board generators, the limits given in **4.3.2** and **4.3.3** may be exceeded provided that the equipment is designed to operate correctly with those conditions.

4.4 Physical environment and operating conditions

4.4.1 General

The electrical equipment shall be suitable for the physical environment and operating conditions of the site where it is intended to be operated. The requirements of **4.4.2** to **4.4.8** specify the physical environment and operating conditions of the majority of machines covered by this Standard. When the special conditions apply or the limits of environmental and operating conditions exceed the specifications of this Standard, an agreement between the user and the supplier (see **4.1**) may be necessary.

4.4.2 Electromagnetic compatibility (EMC)

The electrical equipment shall not generate electromagnetic disturbances above levels that are appropriate for its intended operating environment. In addition, it shall have a level of immunity to electromagnetic disturbances so that it can function correctly in its intended environment.

NOTE 1 The generic EMC standards **JIS C 61000-6-1** and **JIS C 61000-6-2**, and **CISPR 61000-6-3** and **IEC 61000-6-4** give general EMC immunity and emission limits.

NOTE 2 **IEC/TR 61000-5-2** gives guidelines for earthing and cabling of electrical and electronic systems aimed at ensuring EMC. If specific product standards (for example, **JIS B 9704-1**, **IEC 61800-3**, **JIS C 8201-5-2**) exist, they take precedence over these generic standards.

Measures to limit the generation of electromagnetic disturbances, i.e. conducted and radiated emissions shall be as follows.

— Power supply filtering

— Cable shielding

— Enclosures designed to minimize RF radiation

— RF radiation suppression techniques

Measures to enhance the immunity of equipment against conducted and radiated RF disturbance are as follows.

— Design of functional bonding system taking into account the following

  • Sensitive electrical circuits shall be connected to the chassis. Such connecting terminals shall be marked or labelled by the following symbol of **IEC 60417-5020** (DB:2002-10).

  • Connection of the chassis to protective earthing (PE) conductor using a conductor with low RF impedance and as short as practicable

— Sensitive electrical equipment or circuits shall be directly connected to PE conductor or to a functional earthing conductor (FE) (see figure 2) to minimize the common mode disturbance. This FE terminal shall be marked or labelled by the following symbol of **IEC 60417-5018** (DB:2002-10).

— Sensitive circuits shall be separated from the disturbance sources.

— Enclosures designed to minimize RF transmission shall be used.

— Effective wiring method for EMC shall be employed.

  • Using twisted conductors to reduce the effect of differential (normal) mode disturbances

  • Keeping sufficient distance between the conductors emitting disturbances and conductors of sensitive circuits

  • Using cable orientation as close to 90° as practicable when cables cross

  • Wiring conductors as close as practicable to the ground plane

  • Using electrostatic screens and/or electromagnetic shields with a low RF impedance termination.

4.4.3 Ambient air temperature

Electrical equipment shall be capable of operating correctly in the intended ambient temperature. The minimum requirement for all electrical equipment is correct operation between ambient temperatures of 5 °C and 40 °C.

For very hot environments, (for example, hot climates, steel mills, paper mills) and for cold environments, extra requirements may be necessary (see Annex B).

4.4.4 Humidity

The electrical equipment shall be capable of operating correctly when the relative humidity is 50 % or under at a maximum temperature of +40 °C. Higher relative humidities are permissible at lower temperatures (for example, 90 % at +20 °C).

Harmful effects of condensation shall be avoided by design of the equipment or, if necessary, by additional measures (for example, built-in heaters, air conditioners, drain holes).

4.4.5 Altitude

Electrical equipment shall be capable of operating correctly at altitudes up to 1 000 m above sea level. A special agreement (for example, on correct operation at altitudes of 1 000 m or higher above sea level) may be necessary between the supplier and the user (see Annex B).

4.4.6 Contaminants

Electrical equipment shall be adequately protected against the ingress of solids and liquids (see **11.3**).

The electrical equipment shall be adequately protected against contaminants (for example, dusts, acids, corrosive gases, salts) that can be present in the physical environment in which the electrical equipment is to be installed (see Annex B).

4.4.7 Ionizing and non-ionizing radiation

When electrical equipment is subject to radiation (for example, microwave, ultraviolet, lasers, X-rays), additional measures shall be taken to avoid malfunctioning of the equipment and accelerated deterioration of the insulation. A special agreement in regard to this matter may be necessary between the supplier and the user (see Annex B).

4.4.8 Vibration, shock, and bump

Undesirable effects of vibration, shock and bump (including those generated by the machine and its associated equipment and those created by the physical environment) shall be avoided by the selection of suitable equipment, by mounting it away from the machine, or by employing the anti-vibration mountings. A special agreement in regard to the measure for vibration, shock and bump may be necessary between the supplier and the user (see Annex B).

4.5 Transportation and storage

Electrical equipment shall be designed to withstand or suitable precautions shall be taken to protect against the effects of transportation and storage temperatures within a range of −25 °C to +55 °C for long periods and up to +70 °C for short periods not exceeding 24 h. Suitable measures shall be provided to prevent damage from humidity, vibration, and shock. A special agreement in regard to this matter may be necessary between the supplier and the user (see Annex B).

NOTE : PVC insulated cables are susceptible to damage at low temperature.

4.6 Means for convenience of handling

Heavy and bulky electrical equipment that has to be removed from the machine for transport, or that is independent of the machine, shall be provided with suitable means for handling (for example, lifting eyebolt) by cranes or similar equipment.

4.7 Installation

Electrical equipment shall be installed in accordance with the electrical equipment supplier's instructions.

5 Connection of incoming power supply conductors, disconnectors and devices for switching off

5.1 Connection of incoming power supply conductors

Where practicable, the electrical equipment of a machine should be connected to a single power supply. Where another power supply is necessary for certain parts of the equipment (for example, electronic devices that operate at a different voltage from the incoming power supply voltage), that power supply should be derived, as far as is practicable, from devices (for example, transformers, converters) forming part of the electrical equipment of the machine. For large complex machinery comprising a number of widely-located machines working together in a co-ordinated manner, more than one incoming power supply may be used depending upon the site power supply arrangements (see **5.3.1**).

Unless a plug is provided with the machine for the connection to the incoming power supply conductor [see **5.3.2 e**)], the power supply conductor should be directly connected to the power supply disconnector.

Where a neutral conductor is used, it shall be clearly indicated in the technical documentation of the machine, such as in the installation diagram and in the circuit diagram, and a separate insulated terminal labelled N in accordance with **16.1** shall be provided for the neutral conductor (see Annex B).

There shall be no connection between the neutral conductor (N) and the protective bonding circuit (PE) inside the electrical equipment. In addition, the PEN terminal which serve a double purpose of the PE terminal and the N terminal shall not be provided.

Exception : A connection may be made between the N terminal and the PE terminal at the connecting point of the power supply to the machine in the TN-C earthing system [3)].

Note [3)] The TN-C earthing system is one of the earthing systems of power supply and makes the PEN conductor serve a double purpose of the PE conductor and the N conductor in the TN earthing system. For the commercial power supply in Japan, the TT earthing system is used, but the TN earthing system is not. For the earthing system of power supply, there is a description in article 272 of the "interpretation of technical standards for electrical installations", the document published by the Ministry of Economy, Trade and Industry.

All terminals for the incoming power supply connection shall be clearly identified in accordance with **JIS C 0445** or **IEC 60445**, and **16.1**. For the identification of the external protective conductor terminal, see **5.2**.

NOTE : **JIS C 0445** : 1999 (identical with **IEC 60445** : 1988) is slightly different from **IEC 60445** : 1999, which is quoted in **IEC 60204-1** : 2005 (In **JIS C 0445** : 1999, there is no specification on the FE terminal and the FB terminal).

5.2 Terminal for connection to external protective earthing system

For each incoming power supply, a terminal shall be provided in the vicinity of the associated phase conductor terminals for connection of the machine to the external protective earthing system or to the external protective conductor corresponding to the earthing system of power supply.

The terminal shall be such a size as to enable the connection of an external protective copper conductor with a cross-sectional area shown in table 1.

Where an external protective conductor of a material other than copper is used, the terminal size shall be selected accordingly (see **8.2.2**).

NOTE : The size of the terminal for connecting the external protective conductor (PE terminal) shall be determined in accordance with the following procedure.

— Determine the cross-sectional area of the external protective conductor from the cross-sectional area of the phase conductor of power supply in accordance with table 1.

— From the determined cross-sectional area of the external protective conductor, determine the size of the PE terminal to which this protective conductor is connected.

Table 1 Minimum cross-sectional area of external protective conductor (copper)

Cross-sectional area of phase conductor of power supply feeding for equipment S (mm^2)	Minimum cross-sectional area of the external protective conductor (copper) S_p (mm^2) (S_p is determined corresponding to S in left column)
$S \leq 16$	S
$16 < S \leq 35$	16
$S > 35$	$S/2$

At each incoming power supply point, the terminal for the external protective earthing system or the external protective conductor shall be marked or labelled with the letters PE (see **JIS C 0445** or **IEC 60445**).

5.3 Incoming power supply disconnector

5.3.1 General

An incoming power supply disconnector shall be set for the following power supply.

— Each incoming power supply to machine

NOTE 1 The incoming power supply may be connected directly to the machine or via a feeder system. In the feeder systems, the conductor wires, conductor bars, slip-ring assemblies, flexible cable systems (reeled, festooned) and inductive power supply systems may be included.

— Each on-board power supply

The incoming power supply disconnector shall disconnect (isolate) the electrical equipment of the machine from the power supply when required (for example, for work on the machine, including the electrical equipment).

When more than one disconnector is provided, the protective interlock for correct operation shall also be provided in order to prevent a hazardous situation (including damage to the machine or to the work in progress, see NOTE 2).

NOTE 2 The definition of "hazardous situation" is described in **3.9** of **JIS B 9700-1** as follows.

"Circumstance in which a person is exposed to at least one hazard, and the exposure can immediately or over a period of time result in harm."

5.3.2 Type

For the incoming power supply disconnector, one of the following types shall be used.

a) Switch-disconnector, with or without fuses, conforming to **JIS C 8201-3** or **IEC 60947-3**, utilization category AC-23B or DC-23B

NOTE : **JIS C 8201-3** : 2001 is corresponding to **IEC 60947-3** : 1990 (MOD) and is not the same as **IEC 60947-3** : 1999, which is quoted in **IEC 60204-1** : 2005. Ditto for **b**) below.

b) Disconnector, with or without fuses conforming to **JIS C 8201-3** or **IEC 60947-3**, that has an auxiliary contact to break the load circuit with other switching devices in all cases before the opening of the main contacts of the disconnector

c) A circuit-breaker suitable for isolation conforming to **JIS C 8201-2-1** or **JIS C 8201-2-2**

d) Any other switching device conforming to the relevant Japanese Industrial Standard or **IEC** Standard for that product and which meets the isolation requirements of **JIS C 8201-1** as well as a utilization category defined in that product standard as appropriate for on-load switching of motors or other inductive loads

e) Plug/socket combination for a flexible cable for feeding

5.3.3 Requirements

When the input power supply disconnector is one of the types given in **5.3.2 a**) to **d**), it shall satisfy all of the following requirements.

— Capable of isolating the electrical equipment from the power supply and have one OFF (isolated) position and one ON (closed) position marked with "○" and "|" [Symbols in accordance with **IEC 60417-5008** (DB : 2002-10) and **IEC 60417-5007** (DB : 2002-10). See **10.2.2**].

— Having a visible contact gap or a position indicator which cannot indicate OFF (isolated) until all contacts are actually open and the requirements for the isolating function have been satisfied.

— Having an external operating means (for example, handle) on the enclosure of disconnector (exception: power-operated switchgear need not be operable from outside the enclosure where there are other means to open it). Where the external operating means is not intended for emergency operations, it should be coloured black or grey (see **10.7.4** and **10.8.4**).

— Being provided with a means permitting it to be locked in the OFF (isolated) position (for example, by padlocks). When so locked, remote as well as local closing shall be prevented.

— Capable of disconnecting all live conductors of its power supply circuit. However, when the power is supplied in the TN-S earthing system [4], the neutral conductor may or may not be disconnected. In any earthing system, the PE conductor and the PEN conductor shall not be disconnected.

Note [4] The TN-S earthing system is a system in which the PE conductor and the N conductor (neutral conductor) are separated in the TN supply system. The TN-S earthing system is not used for the commercial power supply in Japan.

— Having a breaking capacity sufficient to interrupt the current of the largest motor when stalled together with the sum of the normal operating currents of all other motors and/or loads.

The calculated breaking capacity may be reduced by the use of a proven diversity factor.

When the incoming power supply disconnector is a plug/socket combination, it shall satisfy the following requirements.

— Having the switching capability itself, or be interlocked with a switching device that has a breaking capacity, sufficient to interrupt the current of the largest motor when stalled together with the sum of the normal operating currents of all other motors and/or loads.

The calculated breaking capacity may be reduced by the use of a proven diversity factor. When the interlocked switching device is electrically operated (for example, a contactor), it shall have an appropriate utilization category.

— **a**) to **f**) of **13.4.5**.

NOTE : A suitably rated plug and socket-outlet, cable coupler or coupler for appliance conforming to **JIS C 8285-1** can satisfy these requirements.

Where the incoming power supply disconnector is a plug/socket combination, a switching device with an appropriate utilization category shall be provided for switching the machine on and off. This may be achieved by the use of the interlocked switching device described above.

5.3.4 Operating means

The operating means (for example, a handle) of the incoming power supply disconnector shall be easily accessible and positioned 0.6 m or over up to and including 1.9 m above the servicing level. An upper limit of 1.7 m is recommended.

NOTE : The direction of operation is specified in **JIS B 9706-3**.

5.3.5 Excepted circuits

The following circuits need not be disconnected by the incoming power supply disconnector.

— Power supply circuits for lighting needed during maintenance or repair

— Plug and socket-outlets for the exclusive connection of repair or maintenance tools and equipment (for example, hand drills, testing equipment)

— Undervoltage protection circuits provided only for automatic tripping in the event of power supply failure

— Feeding circuit for equipment that should normally remain energized for correct operation [for example, temperature controlled measuring devices, product (work in progress) heaters, program storage devices]

— Control circuits for interlocking

However, such circuits should be provided with their own disconnector.

In the case where such a circuit is not disconnected by the incoming power supply disconnector, the following requirements shall be satisfied.

— Permanent warning label(s) shall be appropriately placed in the vicinity of the incoming power supply disconnector

— A corresponding statement shall be included in the maintenance manual, and one or more of the following shall apply.

  • A permanent warning label in accordance with **16.1** shall be placed in the vicinity of each excepted circuit

  • The excepted circuit is separated from other circuits

  • The conductors are identified by colour taking into account the recommendation of **13.2.4**.

5.4 Devices for switching off for prevention of unexpected start-up

Devices for switching off for the prevention of unexpected start-up shall be provided with the electrical equipment of machine (for example where, during maintenance, a start-up of the machine or part of the machine can create a hazard).

Such devices shall be appropriate and convenient for the intended use, shall be suitably located, and readily identifiable as to their function and purpose (for example, by a durable marking in accordance with **16.1**).

NOTE 1 Details of prevention of unexpected start-up shall be specified in **JIS B 9714**. This Standard does not address all provisions for prevention of unexpected start-up.

NOTE 2 The definition and explanation of unexpected start-up is also described in **3.29** of **JIS B 9700-1**. The start made by an operator who pushes the start button of a control station without knowing that a maintenance person is intervening in the machine is an unexpected start-up from the standpoint of the maintenance person. The device for switching off for prevention of unexpected start-up is a device for disabling the machine

to start-up while this is opened. For example, the machine does not start-up even if someone pushes a start button accidentally, if this device is opened during the maintenance service.

NOTE 3 It is given in **5.4** that all machines are not always required to be provided with the device for switching off for prevention of unexpected start-up further in addition to the input power supply disconnector given in **5.3**. Depending on the machine (electrical equipment), unexpected start-up may be prevented by opening the incoming power supply disconnector.

Means shall be provided to prevent inadvertent or mistaken closure of the devices for switching off to prevent unexpected start-up either at the operator control station or from other places (see also **5.6**).

The following devices satisfying the disconnecting function may be used as the device for switching off to prevent unexpected start-up.

— Device indicated in **5.3.2**

— Other disconnectors, withdrawable fuse links or withdrawable links only if located in an enclosed electrical operating area (see **3.19**).

Devices not satisfying the disconnecting function (for example, a contactor switched-off by a control circuit) shall not be used other than the case intended to be used for the following situations.

— Inspections

— Adjustments

— Work on the electrical equipment which satisfies the following conditions

  • There is no hazard arising from electric shock (see clause **6**) and burn.

  • The switching off means remains effective throughout the work.

  • The work is of a minor nature (for example, replacement of plug-in devices without disturbing existing wiring).

NOTE 4 The selection of a device will be dependent on the risk assessment by taking into account the intended use of the device. For example, the use of disconnectors, withdrawable fuse links or withdrawable links located in enclosed electrical operating areas can be inappropriate for use by cleaners [see **17.2 b) 12**)].

5.5 Devices for disconnecting electrical equipment

NOTE : The "electrical equipment" given in **5.5** is not the electrical equipment as an aggregate including all electric parts of a machine, but for example, the individual part such as each power circuit, a transformer, a motor, a control circuit (see **3.21**). Although the "devices for disconnecting electrical equipment" required here are basically assumed to be provided separately from the incoming power supply disconnector given in **5.3**, for the simple machine (electrical equipment), even if it is not provided separately from the incoming power supply disconnector, the incoming power supply disconnector may be capable of performing this function. Whether an independent disconnector should be provided or not depends on the risk assessment.

Devices shall be provided for disconnecting (isolating) electrical equipment to enable work to be performed when it is de-energized and isolated. Such devices shall be as follows.

— Appropriate and convenient for the intended use

— Suitably located

— Readily identifiable as to which part(s) or circuit(s) of the equipment is served (for example, by durable marking).

Means shall be provided to prevent inadvertent and/or mistaken closure of these devices either at the controller or from other places (see also **5.6**).

The incoming power supply disconnector (see **5.3**) may, in some cases, satisfy the disconnecting function given in **5.5**. However, where it is necessary to work on individual parts of the electrical equipment of a machine, or on one of a number of machines fed by a common conductor bar, conductor wire or inductive power supply system, a disconnector shall be provided for each part or for each machine requiring separate disconnection.

In addition to the incoming power supply disconnector, the following devices satisfying the disconnecting function may be used.

— Devices indicated in **5.3.2**

— Other disconnectors, withdrawable fuse links and withdrawable links only if located in an electrical operating area (see **3.15**) and relevant information is provided with the electrical equipment [see **17.2 b) 9)** and **17.2 b) 12)**].

NOTE : In the case where protection against electric shock is provided in accordance with **6.2.2 c)**, the withdrawable fuse links or withdrawable links for this purpose are intended for use by skilled or instructed persons.

5.6 Protection against unauthorized, inadvertent/mistaken connection

The devices given in **5.4** and **5.5** located outside an enclosed electrical operating area shall be provided with means to secure them in the OFF position (disconnected state) (for example, padlocking, trapped key interlocking). When so secured, remote as well as local power restore shall be prevented.

Where a non-lockable disconnector (for example, withdrawable fuse-links, withdrawable links) is located inside an enclosed electrical operating, other means of protection against the power restore (for example, warning labels in accordance with **16.1**) shall be provided.

When a plug/socket combination given in **5.3.2 e)** is so located that it can be kept under the immediate supervision of the person carrying out the work so as not to occur the unintended connection, means for securing in the disconnected state need not be provided.

6 Protection against electric shock

6.1 General

The electrical equipment shall provide protection of persons against electric shock from the following.

— Direct contact (see **6.2** and **6.4**)

— Indirect contact (see **6.3** and **6.4**)

The recommended measures for protection against electric shock selected from **JIS C 60364-4-41** are specified in **6.2**, **6.3** and **6.4**. Where these recommended measures are not practicable due to the physical restriction or operational conditions, other measures from **JIS C 60364-4-41** may be used.

6.2 Protection against direct contact

6.2.1 General

For each circuit or part of the electrical equipment, the measures of either **6.2.2** or **6.2.3** and, where applicable, **6.2.4** shall apply.

Exception: Where these measures are not appropriate, other measures for protection against direct contact (for example, by using barriers, placing out of reach, using obstacles, using structure or installation techniques that prevent access) as defined in **JIS C 60364-4-41** may be applied (see **6.2.5** and **6.2.6**).

When the equipment is located in the places open to all persons including children, measures of either **6.2.2** with a minimum degree of protection against direct contact corresponding to IP4X or IPXXD (see **JIS C 0920**) or **6.2.3** shall apply.

NOTE : The degrees of protection provided by the enclosures are shown in Annex JC.

6.2.2 Protection by enclosures

Live parts shall be located inside enclosures that conform to the relevant requirements of clause **4**, clause **11** and clause **14** and that provide protection (degree) against direct contact of at least IP2X or IPXXB.

Where the top surfaces of the enclosures are readily accessible, the minimum degree of protection against direct contact provided by the top surface shall be IP4X or IPXXD.

Opening an enclosure (i.e. opening doors, lids, covers, and the like) shall be possible only under one of the following conditions.

a) The use of a key or tool is necessary for access. For the enclosed electrical operating areas (see **3.19**), see **JIS C 60364-4-41** or **IEC 60439-1**.

NOTE 1 The use of a key or tool is intended to restrict access to skilled or instructed persons [see **17.2 b) 12)**].

All live parts that are likely to be touched when resetting or adjusting devices intended for such operations while the equipment is still connected to the power supply shall provide the protection (degree) against direct contact to at least IP2X or IPXXB. Other live parts inside doors shall provide the protection (degree) against direct contact to at least IP1X or IPXXA.

b) The disconnection of live parts inside the enclosure shall be completed before the enclosure can be opened.

This may be accomplished by interlocking the door with a disconnector (for example, the incoming power supply disconnector) so that the door can only be opened

when the disconnector is open and so that the disconnector can only be closed when the door is closed.

Exception: A special device or tool (see NOTE 2) as prescribed by the supplier can be used to disable (bypass) this interlock when the following conditions are satisfied.

— It is possible at all times while the interlock is disabled to open the disconnector and lock the disconnector in the OFF position, or otherwise prevent unauthorised closure of the disconnector.

— Upon closing the door, the interlock is automatically restored (i.e. upon opening the door next, it is automatically disconnected.)

— All live parts that are likely to be touched when resetting or adjusting devices intended for such operations while the equipment is still connected to the power supply shall be protected against direct contact to at least IP2X or IPXXB. Other live parts inside the doors shall be protected against direct contact to at least IP1X or IPXXA.

— Information related to protection against electric shock is provided with the electrical equipment [see **17.2 b) 9)** and **17.2 b) 12)**].

NOTE 2 The special device or tool is intended for use only by skilled or instructed persons [see **17.2 b) 12)**].

Measures shall be provided to restrict access to live parts behind doors not directly interlocked with the disconnectors to skilled or instructed persons [See **17.2 b) 12)**].

All parts that are still live after switching off the disconnector (see **5.3.5**) shall be protect against direct contact to at least IP2X or IPXXB (degree). Such parts shall be marked with a warning sign in accordance with **16.2.1** (see also **13.2.4** for identification of conductors by colour).

Requirements for the marking of the warning sign given in **16.2.1** may be omitted in the following cases.

— Parts that can be live only because of connection to the interlocking circuits and that are distinguished by colour as potentially live in accordance with **13.2.4**.

— The power supply terminals of the incoming power supply disconnector when the latter is mounted alone in a separate enclosure.

c) Opening without the use of a key or a tool and without disconnection of live parts shall be possible only when all live parts are protected against direct contact to at least IP2X or IPXXB (degree). Where barriers provide this protection, either they shall require a tool for their removal or all live parts protected by them shall be automatically disconnected when the barrier is removed.

NOTE 3 Where protection against direct contact is achieved in accordance with **6.2.2 c**), and a hazard may be caused by manual actuation of devices (for example, manual closing of contact of contactors or relays), such operation should be prevented by barriers or obstacles that requires a key of a tool for their removal.

6.2.3 Protection of live part by insulation

Live parts protected by insulation shall be completely covered with insulation that can only be removed by destruction. Such insulation shall be capable of withstanding the mechanical, chemical, electrical, and thermal stresses to which it can be subjected under the normal use conditions.

NOTE : Paints, varnishes, lacquers and similar products alone are generally considered to be inadequate for protection against electric shock under the normal operating conditions.

6.2.4 Protection against residual voltage

Live parts having a residual voltage over 60 V after the power supply has been disconnected shall be discharged to 60 V or under within 5 s after disconnection of the power supply voltage, provided that this rate of discharge does not interfere with the proper functioning of the equipment. Parts having a stored charge of 60 μC or under are exempted from this requirement. Where this discharging rate of 5 s or under would interfere with the proper functioning of the equipment, a durable warning notice drawing attention to the hazard and stating the discharge time required before the enclosure may be opened shall be displayed at an easily visible place on or immediately adjacent to the enclosure containing the capacitances.

In the case of plugs or similar devices, the withdrawal of which results in the exposure of conductor (for example, pins), the discharge time shall be 1 s or under, otherwise such conductors shall be protected against direct contact to at least IP2X or IPXXB (degree).

If neither a discharge time of 1 s nor a protection of at least IP2X or IPXXB can be achieved (for example, in the case of the removable current collectors on conductor wires, conductor bars, or slip-ring assemblies, see **12.7.4**), addition of the switch capable of shutting off the stored charge or an appropriate warning means (for example, a warning notice in accordance with **16.1**) shall apply.

6.2.5 Protection by barriers

For the protection by barriers, **412.2** of **JIS C 60364-4-41** shall apply.

NOTE : In **412.2.1** to **412.2.4** of **JIS C 60364-4-41**, the protection by barriers or enclosures are specified. The specification for protection by barriers among them shall apply to **6.2.5** of this Standard.

6.2.6 Protection by placing out of reach or protection by obstacles

For protection by placing out of reach, **412.4** of **JIS C 60364-4-41** shall apply. For protection by obstacles, **412.3** of **JIS C 60364-4-41** shall apply.

For the conductor wire systems or the conductor bar systems with a degree of protection less than IP2X, see **12.7.1**.

6.3 Protection against indirect contact

6.3.1 General

Protection against indirect contact (see **3.29**) is intended to prevent the hazardous situations due to an insulation fault between the live parts and the exposed conductive parts.

For each circuit or part of the electrical equipment, at least one of the following measures shall be adopted.

— Measures to prevent the occurrence of a touch voltage (given in **6.3.2**)

— Automatic disconnection of the power supply before occurrence of hazardous touch voltage (given in **6.3.3**).

NOTE 1 The risk of injury from a touch voltage depends on the magnitude of touch voltage and the exposure duration.

NOTE 2 For classes of equipment and protective provisions, see **JIS C 0365**. The definition of "Class" specified in **JIS C 0365** is shown in Annex JD.

6.3.2 Prevention of the occurrence of a touch voltage

6.3.2.1 General

The measures to prevent the occurrence of a touch voltage shall be as follows.

— Employment of Class II equipment (see Annex JD) or by equivalent insulation (according to **6.3.2.2**)

— Electrical separation (according to **6.3.2.3**)

6.3.2.2 Protection by employment of Class II equipment or by equivalent insulation

This protection measure is intended to prevent the occurrence of touch voltages on the accessible parts through a fault in the basic insulation.

This protection is provided by the execution of one or more of the following measures.

— Employment of Class II electrical devices or apparatus (double insulation, reinforced insulation or by equivalent insulation conforming to **JIS C 0365**)

— Employment of switchgear and controlgear assemblies having total insulation conforming to **IEC 60439-1**

— Employment of supplementary insulation or reinforced insulation conforming to **413.2** of **JIS C 60364-4-41**

6.3.2.3 Protection by electrical separation

Electrical separation of an individual circuit is intended to prevent a touch voltage through contact with exposed conductive part that can be energized by a fault in the basic insulation of the live parts of that circuit.

For this type of protection, the requirements of **413.5** of **IEC 60364-4-41** shall apply.

6.3.3 Protection by automatic disconnection of power supply

This protection measure shall be so that the conductor is disconnected by the automatic actuation of a protective device in case of an insulation fault. This breakage shall be performed within a sufficiently short time within which the touch voltage is not hazardous. The permissible breakage times applied to the TN earthing systems are shown in Annex A. The permissible breakage times applied to the TT earthing systems (mainly used in Japan) are shown in Annex JA.

For this measure, the co-ordination of the following items is necessary.

— The type of power supply and earthing system

— The impedance of each part of the protective bonding system

— The characteristics of the protective devices that detect insulation fault

Automatic disconnection of the power supply of any circuit affected by an occurrence of insulation fault is intended to prevent a hazardous situation resulting from a touch voltage.

This protective measure consists of the following two.

— Protective bonding of exposed conductive parts (see **8.2.3**)

— Any of the following **a**) to **c**)

a) In TN earthing systems, overcurrent protective devices for automatic disconnection of the power supply on occurrence of an insulation fault

b) In TT earthing systems, residual current protective devices (residual current disconnector) for the automatic disconnection of the power supply on detection of an insulation fault from a live part to exposed conductive parts or earthing

NOTE 1 In TT earthing systems, for the installation place of the residual current disconnector, it is considered to be necessary to agree between the user and the supplier of the electrical equipment beforehand (see Annex B). When the residual current disconnector is not provided in the power supply circuit to the electrical equipment (outside the electrical equipment), or the residual current disconnector provided does not satisfy the requirements given in Annex JA, it becomes necessary to provide the ground fault interrupter inside the electrical equipment. When two or more residual current disconnectors exist in a power supply system, the coordination of characteristics (sensitivity current, interrupting time, etc.) of each protective device is needed.

NOTE 2 When the occurrence of a touch voltage can be prevented by adopting the measures in **6.3.2**, the residual current disconnector may or may not be used (see **6.3.1**).

c) In IT earthing systems, insulation monitoring devices or residual current protective devices for promoting automatic disconnection. Except where a protective device is provided to break the power supply in case of the first ground fault, an insulation monitoring device shall be provided to indicate the occurrence of a first fault from a live part to exposed conductive parts or earthing. This insulation monitoring device shall initiate an audible and/or visual signal which shall continue as long as the fault persists.

NOTE 3 In large machine, an employment of means to find the ground fault point can facilitate maintenance.

Where automatic disconnection of **a**) is provided, but disconnection within the time given in clause **A.1** cannot be assured, supplementary bonding satisfying the requirements of clause **A.3** shall be provided.

6.4 Protection by use of PELV

NOTE : PELV (Protective Extra-Low Voltage) refers to a voltage which does not exceed ELV (Extra-Low Voltage) in a steady state and a single fault condition (except the ground fault failure of other circuit). The PELV circuit is earthed. ELV circuit which is not earthed is called SELV. Although the voltage value of ELV is under 50 V a.c. and under 120 V d.c. for the definition of **IEC 60449**, according to the application standards, the required value of PELV may be different from this. The severer value than this is given in **6.4.1** of this Standard.

6.4.1 General requirements

The use of PELV (Protective Extra-Low Voltage) is to protect persons against electric shock from indirect contact and limited area direct contact (see **8.2.5**).

PELV circuit shall satisfy all of the following **a**) to **e**) conditions.

a) The nominal voltage shall not exceed the following values.

— 25 V a.c. (r.m.s.) or 60 V d.c. (ripple-free) when the equipment is normally used in dry places and when large area contact of live parts with the human body is not expected

— 6 V a.c. (r.m.s.) or 15 V d.c. (ripple-free) in all other cases

NOTE : Ripple-free herein is defined for a sinusoidal ripple voltage as a ripple content of not exceeding 10 % r.m.s.

b) One side of the circuit or one point of the power supply of that circuit shall be connected to the protective bonding circuit.

c) Live parts of PELV circuits shall be electrically separated from other live circuits. Electrical separation shall satisfy the required condition between the primary and secondary circuits of a safety isolating transformer (see **IEC 61558-1** and **IEC 61558-2-6**)

d) Conductors of each PELV circuit shall be physically separated from those of any other circuit. When this requirement is impracticable, the insulation means of **13.1.3** shall apply.

e) Plugs and socket-outlets for a PELV circuit shall conform to the following.

1) Plugs shall not be capable of entering to the socket-outlets of other voltage systems.

2) Socket-outlets shall not admit plugs of other voltage systems.

6.4.2 Power supply for PELV

The power supply for PELV shall be one of the following.

— A safety isolating transformer conforming to **IEC 61558-1** and **IEC 61558-2-6**

— A power supply providing a degree of safety equivalent to that of the safety isolating transformer (for example, a motor generator with winding providing equivalent isolation)

— An electrochemical power supply (for example, a battery) or another power supply independent of a higher voltage circuit (for example, a diesel-driven generator)

— An electronic power supply conforming to appropriate standards specifying measures to be taken to ensure that the voltage at the outgoing terminals can not exceed the values given in **6.4.1** even in the case of an internal fault

7 Protection of equipment

NOTE : The "equipment" given in clause **7** mainly means the single unit (a transformer, motor, conductor, etc.) (see **3.21**).

7.1 General

In clause **7**, the measures to be taken to protect equipment against the following effects are specified.

— Overcurrent due to a short-circuit accident

— Overload and/or loss of cooling of motors

— Abnormal temperature

— Loss of power supply voltage or voltage reduction

— Overspeed of machines and machine elements

— Ground fault current or residual current

— Incorrect phase sequence

— Overvoltage due to lightning and switching surges

7.2 Overcurrent protection

7.2.1 General

Overcurrent protection shall be provided where that the circuit current in a machine (equipment) may exceed either the rating of any component or the permissible current-carrying capacity of conductors, whichever is the smaller. The ratings or settings to be selected shall be given in **7.2.10**.

7.2.2 Power supply conductor

NOTE : The power supply conductor given in **7.2.2** shall be the power supply wire generally not included in the construction of electrical equipment (prepared by the user of electrical equipment) outward the input terminal of the electrical equipment.

Unless otherwise specified by the user, the supplier of the electrical equipment is not responsible for providing the overcurrent protective device for the power supply conductors to the electrical equipment (see Annex B).

The supplier of the electrical equipment shall state the data necessary for selecting the overcurrent protective device on the installation connection diagram (see **7.2.10** and **17.4**).

7.2.3 Power circuit

Devices for detection and breakage of overcurrent, selected in accordance with **7.2.10**, shall be applied to each live conductor.

The following conductors shall not be disconnected without disconnecting all associated live conductors.

— The neutral conductor of a.c. power supply circuits

— The earthing conductor of d.c. power supply circuits

— Conductors of d.c. power supply bonded to exposed conductive parts of mobile machines

Where the cross-sectional area of the neutral conductor is at least equivalent to that of the phase conductors, it is not necessary to provide a overcurrent detector nor a disconnector for that neutral conductor. For a neutral conductor with a cross-sectional area smaller than that of the associated phase conductors, the overcurrent protection specified in **524** of **JIS C 60364-5-52** shall apply.

In IT earthing systems, the neutral conductor should not be used. When the neutral conductor is used, however, the measures specified in **431.2.2** of **JIS C 60364-4-43** shall apply.

7.2.4 Control circuits

Conductors of control circuits directly connected to the incoming power supply and of circuits supplying control circuit transformers shall be protected against the overcurrent in accordance with **7.2.3**.

Conductors of control circuits supplied by a control circuit transformer or d.c. power supply shall be protected against the overcurrent according to the following (see also **9.4.3.1**).

— An overcurrent protective equipment shall be inserted into the switched conductor in control circuits connected to the protective bonding circuit.

— The following shall apply to control circuits not connected to the protective bonding circuit.

  • When conductors of same cross-sectional area are used in all control circuits, an overcurrent protective device shall be inserted into the switched conductor.

  • When conductors of different cross-sectional areas are used in different sub-circuits, an overcurrent protective device shall be inserted into both switched and common conductors of each sub-circuit.

7.2.5 Socket-outlets and conductors for feeding them

Overcurrent protection shall be provided for the circuits feeding the general purpose socket-outlets intended primarily for supplying power to maintenance equipment. Overcurrent protective devices shall be provided in the unearthed live conductors of each circuit feeding such socket-outlet.

7.2.6 Lighting circuits

All unearthed conductors of power supply circuits for lighting shall be protected against the effects of short-circuits by the overcurrent protective devices only for the power supply circuits for lighting separate from those protecting other circuits.

7.2.7 Transformers

Transformers shall be protected against overcurrent in accordance with the manufacturer's instructions. Such protection for transformer shall satisfy the following. (see also **7.2.10**).

— Nuisance tripping due to transformer inrush currents shall be avoided.

— A winding temperature rise in excess of the permissible value for the insulation class of transformer when it is subjected to the effects of a short-circuit at its secondary terminals shall be avoided.

The type and set value of actuating current (trip current of circuit disconnector, fusing current of fuse) of the overcurrent protective device should be in accordance with the recommendations of the transformer supplier.

7.2.8 Location of overcurrent protective devices

An overcurrent protective device shall be located at the point where a reduction in the cross-sectional area of conductors or another change reduces the current-carrying capacity of the conductors except where all the following conditions are satisfied.

— The current-carrying capacity of all conductors shall be at least equal to that of the load.

— The part of conductor between the point of reduction of current-carrying capacity and the position of the overcurrent protective device shall not exceed 3 m.

— The conductor shall be installed in such a manner as to reduce the possibility of a short-circuit, for example, protected by an enclosure or duct.

7.2.9 Overcurrent protective devices

The rated short-circuit breaking capacity shall be at least equal to the prospective fault current at the set point of the overcurrent protective device. Where the short-circuit current to an overcurrent protective device can include additional currents other than from the power supply (for example, motors, power factor correction capacitors), those currents shall be taken into consideration.

A lower breaking capacity is permissible where another overcurrent protective device, for example, the overcurrent protective device for the power supply conductors (see **7.2.2**) having the necessary breaking capacity is set on the power supply side of the electrical equipment. In this case, the characteristics of two overcurrent protective devices shall be co-ordinated so that the let-through energy (I^2t) of two devices in series does not exceed that which can be withstood without damage to the overcurrent protective device on the load side and to the conductors protected thereby (see Annex A of **JIS C 8201-2-1**).

NOTE : The use of such a co-ordination of overcurrent protective devices can result in the correct operation of both overcurrent protective devices.

Where fuses are used as overcurrent protective devices, a type readily available shall be selected or arrangements shall be made for the supply for spare parts.

7.2.10 Rating and setting value of operating current of overcurrent protective device

The rated current of fuses or the setting current of other overcurrent protective devices shall be made as low as possible, but adequate for the anticipated overcurrent

(for example, during starting of motors or energizing of transformers). When selecting these protective devices, consideration shall be given to the protection of switching devices against damage due to the overcurrents (for example, welding of contacts).

The rated current or set value of operating current of an overcurrent protective device is determined by the permissible current of the conductors to be protected and the maximum permissible breakage time t. The permissible current of the conductor can be determined in accordance with **12.4** and **D.2** and the maximum permissible breakage time t in accordance with **D.3**. In this case, the needs of co-ordination with other electrical devices in the protected circuit shall be considered.

7.3 Protection against overheating of motors

7.3.1 General

Protection against overheating shall be provided for each motor rated at over 0.5 kW.

Exception: In applications where an automatic stop of the motor operation is unacceptable (for example, fire pumps), the means of detection shall give a warning signal to which the operator can respond.

Protection of motors against overheating can be achieved by the following.

— Overload protection (given in **7.3.2**)

NOTE 1 Overload protective devices detect the time and current relationship (I^2t) in a circuit that are in excess of the rated full load of the circuit and initiate the appropriate control responses.

— Over-temperature protection (given in **7.3.3**)

NOTE 2 Temperature detection devices detect the over-temperature and initiate appropriate control responses.

or

— Current-limiting protection (given in **7.3.4**)

Automatic restarting of any motor after the actuation of over-temperature protective function shall be prevented where this may cause a hazardous situation, or damage to the machine or to the work in progress.

7.3.2 Overload protection

Where overload protection is provided, the overload in each live conductor except for the neutral conductor shall be detected. However, where the overload detector for motor is not used for cable overload protection, the number of overload detectors may be reduced upon the request of the user by installing the overload detector limited to part of live conductors (see also **D.2**). For single-phase or d.c. power supply motors, detection in only one unearthed live conductor is permitted.

Where the overload protection is achieved by the switching device, it shall break all live conductors at overload. The breakage of the neutral conductor is not necessary for overload protection.

For motors with special duty ratings required to start or to brake frequently (for example, motors for rapid traverse, locking, rapid reversal, or sensitive drilling), it may be difficult to provide overload protection with a time constant comparable with that

of the winding to be protected. In this case, appropriate protective devices designed to accommodate special duty motors or over-temperature protection (see **7.3.3**) may be necessary.

For motors that cannot be overloaded (for example, torque motors, motion drives protected by mechanical overload protective devices), the electrical overload protective device is not required.

7.3.3 Over-temperature protection

Motors should be provided with the over-temperature protection (see **IEC 60034-11**) in situations where the cooling may be impaired (for example, dusty environments). Depending on the type of motor, protection under stalled condition or phase loss condition is not always ensured by the over-temperature protection, and additional protection should then be provided.

Over-temperature protection is also recommended for motors that cannot be overloaded (for example, torque motors, motion drives protected by mechanical overload protective device) where the possibility of over-temperature may exists (for example, due to reduced cooling).

7.3.4 Current-limiting protection

Where the protection against the effects of overheating in three-phase motor is achieved by the current limitation, the number of current limitation devices may be reduced from 3 to 2 (see **7.3.2**). For motors operating by single-phase a.c or d.c. power supplies, current limitation in only unearthed live conductor is permitted.

7.4 Abnormal temperature protection

Resistance heating or other circuits which may cause extremely high temperature (for example, due to short-time rating or loss of cooling medium) and therefore may cause a hazardous situation shall be provided with a suitable detection means to initiate an appropriate control response.

7.5 Protection against loss of power supply or voltage reduction and subsequent restoration

Where a loss of power supply or a voltage reduction and subsequent restoration may cause a hazardous situation, damage to the machine or damage to the work in progress, undervoltage protection (for example, breakage of power supply to the machine) actuated at a predetermined voltage level shall be provided.

Where the machine operation can allow for a loss of power supply or a voltage reduction for a short period, a delayed undervoltage protective device may be provided. In this case, the actuation of the undervoltage protective device shall not impair the operation of any stopping control of the machine.

Upon restoration of the voltage or upon power-on of the power supply, automatic or unexpected restarting of the machine shall be prevented where such a restart may cause a hazardous situation.

Where only a part of the machine or of the group of machines working together in a co-ordinated manner is affected by the voltage reduction or the loss of power supply, the undervoltage protection shall initiate appropriate control responses to ensure co-ordination of protective function.

7.6 Overspeed protection of motor

Overspeed protection shall be provided where overspeeding may cause a hazardous situation taking into account measures in accordance with **9.3.2**. The overspeed protection shall initiate appropriate control responses and shall prevent automatic restarting.

The overspeed protection should operate in such a manner that the motor or its load does not exceed the mechanical speed limit.

NOTE : A centrifugal switch or speed limit monitor, for example, may be used for the overspeed protection.

7.7 Ground fault (residual current) current protection

In addition to the overcurrent protection for automatic disconnection given in **6.3**, the ground fault (residual current) protection may be provided to reduce the damage to equipment due to ground fault currents less than the detection level of the overcurrent protection.

The set value of current of the protective devices shall be as low as practicable but consistent with correct operation of the equipment.

7.8 Phase sequence protection

Where an incorrect phase sequence of the power supply voltage may cause a hazardous situation or damage to the machine, phase sequence protection shall be provided.

NOTE : Examples of the operation by an incorrect phase sequence are as follows.

— A machine transferred from one power supply to another

— A mobile machine with a means for connection (terminal, etc.) to an external power supply

7.9 Protection against overvoltages due to lightning and to switching surges

Protective devices may be provided to protect against the effect of overvoltage due to lightning or to switching surges.

In that case the protective devices shall be provided as follows.

— Devices for the suppression of overvoltages due to lightning surges shall be connected to the incoming terminals of the power supply disconnector.

— Devices for the suppression of overvoltages due to switching surges shall be connected across the terminals of all equipment requiring such protection.

8 Equipotential bonding

8.1 General

Requirements for protective bonding and functional bonding are specified in this clause. Those concepts are shown in figure 2.

NOTE : Both protective bonding (see **3.43**) and functional bonding (see **3.27**) are equipotential (see **3.22**).

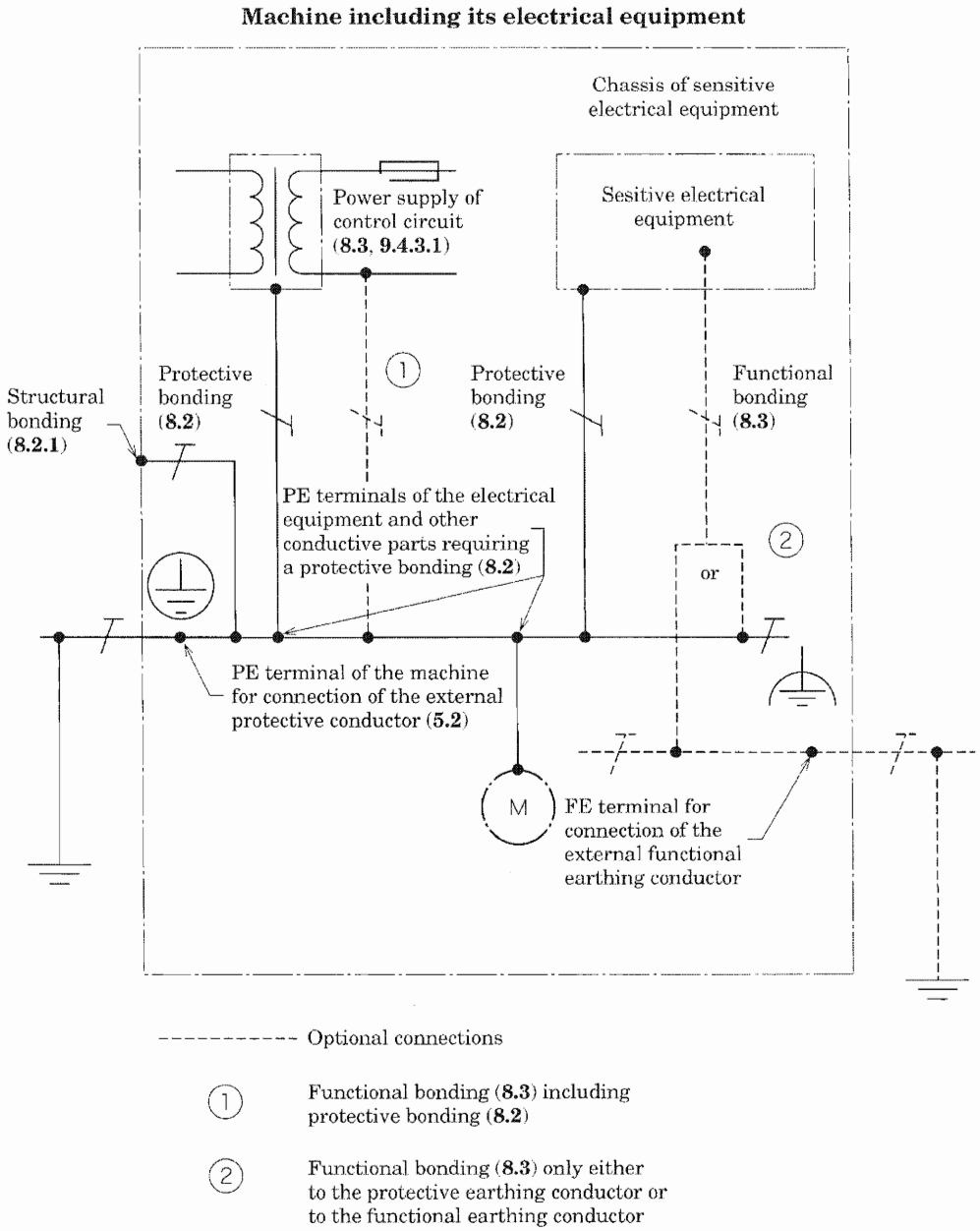
Protective bonding is a basic provision for fault protection to enable protection of persons against electric shock from indirect contact (see **6.3.3** and **8.2**).

The objective of functional bonding is to minimize the following items.

— Undesirable effects on the machine operation due to an insulation failure

— Undesirable effects on the machine operation due to electromagnetic disturbances to sensitive electrical equipment

Normally functional bonding is achieved by connection to the protective bonding circuit; however, where the level of electromagnetic disturbances on the protective bonding circuit is not sufficiently low for proper functioning of electrical equipment, it may be necessary to connect the functional bonding circuit to a separate functional earthing conductor (see figure 2).



NOTE : The "functional earthing conductor" was previously referred to as "noiseless earth conductor" and the "FE" terminal was previously designated as "TE" (see **JIS C 0445** and **IEC 60445**).

Figure 2 Example of equipotential bonding for electrical equipment of a machine

8.2 Protective bonding circuit

8.2.1 General

The protective bonding circuit is constructed with the following.

— PE terminal (see **5.2**)

— The protective conductors in the equipment of the machine (including sliding contacts where they are part of the protective bonding circuit)

— The exposed conductive parts and conductive structural parts of the electrical equipment

— Those extraneous conductive parts which form the structure of the machine (see **3.24**)

All parts of the protective bonding circuit shall be so designed that they are capable of withstanding the highest thermal stress and mechanical stress caused by the ground fault currents flowing in that part of the protective bonding circuit.

Where the conductance of structural parts of the electrical equipment or of the machine is smaller than that of the minimum protective conductor connected to the exposed conductive parts, a supplementary bonding conductor shall be provided. This supplementary bonding conductor shall have a cross-sectional area of 50 % or over of that of the corresponding protective conductor.

If the power supply of the IT earthing system is used, the machine structural part shall be part of the protective bonding circuit and insulation monitoring device shall be provided. See **6.3.3 c**).

Conductive structural parts of equipment in accordance with **6.3.2.2** need not be connected to the protective bonding circuit. Extraneous conductive parts which form the structure of the machine need not be connected to the protective bonding circuit where all the equipment provided is in accordance with **6.3.2.2**.

Exposed conductive parts of equipment in accordance with **6.3.2.3** shall not be connected to the protective bonding circuit.

8.2.2 Protective conductors

Protective conductors shall be identified in accordance with **13.2.2**.

Copper conductors are preferred. Where a conductor material other than copper is used, its electrical resistance per unit length shall not exceed that of the permissible copper conductor, and such conductors shall be 16 mm^2 or over in cross-sectional area.

The cross-sectional area of protective conductors shall be determined in accordance with the following requirements.

— **543** of **JIS C 60364-5-54**

or

— **7.4.3.1.7** of **IEC 60439-1**, as appropriate

This requirement is met in most cases where the relationship between the cross-sectional area of the determined protective conductor and the cross-sectional area of the associated phase conductor satisfies table 1 (see **5.2**).

See also **8.2.8**.

8.2.3 Continuity of protective bonding circuit

All exposed conductive parts shall be connected to the protective bonding circuit in accordance with **8.2.1**.

Exception: Those corresponding to **8.2.5** are exceptional.

Where a part of electrical equipment is removed for any reason (for example, routine maintenance), the continuity of the protective bonding circuit for the remaining parts shall not be interrupted.

Bonding connecting points shall be so designed that the current-carrying capacity is not impaired by mechanical, chemical, or electrochemical influences. Where enclosures and conductors of aluminium or aluminium alloys are used, particular consideration should be given to the possibility of electrolytic corrosion.

Metal ducts of flexible or rigid construction and metallic cable sheaths shall not be used as protective conductors. Nevertheless, such metal ducts and the metal sheathing of all connecting cables (for example, cable armouring, lead sheath) shall be connected to the protective bonding circuit.

Where the electrical device is mounted on lids, doors or cover plates, continuity of the protective bonding circuit shall be ensured. Because of this, the usage of protective conductor (see **8.2.2**) is recommended. Otherwise, fastenings, hinges or sliding contacts designed to have a low resistance shall be used (see Test 1 of **18.2.2**).

The continuity of the protective conductor in cables exposed to damage (for example, flexible trailing cables) shall be ensured by appropriate measures (for example, monitoring).

For the requirement for the continuity of the protective conductor using the conductor wires, conductor bars and slip-ring assemblies, see **12.7.2**.

8.2.4 Exclusion of switching device from the protective bonding circuit

The protective bonding circuit shall not incorporate a switching device or an overcurrent protective device (for example, switch, fuse).

No means of disconnection of the protective bonding conductor shall be provided.

Exception: Links for test or measurement that cannot be opened without the use of a tool and that are located in an enclosed electrical operating area is exceptional.

Where the continuity of the protective bonding circuit can be disconnected by removable current collectors or plug/socket combinations, the contact of protective bonding circuit shall be closed earlier than the contact of the live conductor at the connection and opened at the disconnection. This also applies to the withdrawable plug-in units (see also **13.4.5**).

8.2.5 Parts need not be connected to the protective bonding circuit

It is not necessary to connect the exposed conductive parts to the protective bonding circuit where the parts are mounted so that they do not constitute a hazard because of the following reasons.

— too small in size to be touched or grasped with the hand (under approx. 50 mm × 50 mm)

— located so that either contact with live parts or an insulation failure is unlikely occurred

This provision is applied to small parts such as screws, rivets, and nameplates and to parts inside an enclosure irrespective of the size thereof (for example, electromagnets of contactors or relays and mechanical parts of devices) (see also **410.3.3.5** of **JIS C 60364-4-41**).

8.2.6 Protective conductor connecting points

All protective conductors shall be connected in accordance with **13.1.1**. The protective conductor connecting points shall not be used as other function or not intended, for example, to mount or connect appliances or parts.

Each connecting point of protective conductor shall be marked or labelled as such using the symbol of **IEC 60417-5019** (DB:2002-10) or with the letters PE (the graphical symbol is preferred), by use of the bicolour combination green-and-yellow, or by any combination of these.

8.2.7 Mobile machines

On mobile machines with on-board power supplies, the protective conductors, the conductive structural parts of electrical equipment and extraneous conductive parts which form the structure of the machine shall all be connected to a protective bonding terminal to provide protection against electric shock. Where a mobile machine is connected to an external power supply, the external protective conductor shall be connected to this protective bonding terminal.

NOTE : When electrical energy is supplied from the self-contained power supply in stationary, mobile or movable equipment and when the external power supply is not connected (for example, when an on-board battery charger is not connected to the external power supply), there is no need to connect such equipment to an external protective conductor.

8.2.8 Additional protective bonding requirements for electrical equipment having earthing leakage currents of over 10 mA (a.c. and d.c.)

NOTE 1 Earthing leakage current is defined as "current flow from the live parts of an installation to earth in the absence of an insulation fault" (see **IEV 442-01-24**). This current may have a capacitive component including that resulting from the capacitor in use.

NOTE 2 Most adjustable speed electrical power drive systems that comply with relevant specifications of **IEC 61800** series shall have an earthing leakage current of over 3.5 mA a.c. A touch current measurement method is specified as a type test in **IEC 61800-5-1** to determine the earthing leakage current of an adjustable speed electrical power drive system.

Where the electrical equipment (for example, adjustable speed electrical power drive systems and information technology equipment) has an earthing leakage current of over 10 mA (a.c. or d.c.), one or more of the following **a**) to **c**) conditions shall be satisfied.

a) The protective conductor shall have a cross-sectional area of 10 mm^2 or over for copper conductor or 16 mm^2 or over for aluminium conductor through its total length.

b) A part of the protective conductor which has a cross-sectional area of under 10 mm^2 for copper conductor or 16 mm^2 for aluminium conductor, shall be provided with an additional protective conductor of at least the same cross-sectional area as that of the protective conductor.

NOTE 3 This may require another connection terminal for the additional protective conductor.

c) The power supply shall be disconnected automatically in case of loss of continuity of the protective conductor.

To prevent difficulties associated with electromagnetic disturbances, the requirements of **4.4.2** shall also apply to the installation of duplicate protective conductors.

In addition, a warning label shall be provided adjacent to the PE terminal, and where necessary on the nameplate of the electrical equipment. The information provided under **17.2 b) 1)** shall include information about the earthing leakage current and the minimum cross-sectional area of the external protective conductor.

8.3 Functional bonding

Protection against maloperation as a result of insulation failures of the control circuit can be achieved by connecting to a common conductor of the control circuit in accordance with **9.4.3.1**.

Regarding functional bonding to avoid maloperation due to electromagnetic disturbance, see **4.4.2.**

8.4 Measures to limit the effects of high leakage current

The effects of high leakage current can be restricted to the equipment having the high leakage current by connection of that equipment to a dedicated power supply transformer having separate windings. In this case, the protective bonding circuit shall be connected to both of the exposed conductive parts of the equipment and the secondary winding of the transformer. The protective conductor between the equipment and the secondary winding of the transformer shall satisfy one or more of the requirements of **a)** to **c)** in **8.2.8**.

9 Control circuits and control functions

9.1 Control circuits

9.1.1 Power supply of control circuit

Where the control circuits are supplied from the a.c. power supply, transformers for the control circuit shall be used. Such a transformer shall be the separate-winding type (separating transformers). Where several transformers are used, the windings of those transformers should be connected in such a manner that each of the secondary voltages are in phase.

Where control circuits using d.c. power supply converted from an a.c. power supply are connected to the protective bonding circuit (see **8.2.1**), the a.c. power supply supplied to that d.c. power supply for control shall be supplied from a separate winding of the transformer for the control circuit or from another transformer for the control circuit.

NOTE : The switching power supplies using transformers of separate-winding type (separating transformers) of **IEC 61558-2-17** meet this requirement.

Transformers of the power supply for control is not necessarily used for the machines with a single motor starter and/or a maximum of two control devices (for example, interlock device, start/stop control device).

9.1.2 Voltage for control circuit

The nominal voltage of the control circuit shall be consistent with the value for the correct function of the control circuit. The nominal voltage of the circuit shall not exceed 277 V when supplied from a transformer.

9.1.3 Protection

Control circuits shall be provided with overcurrent protection in accordance with **7.2.4** and **7.2.10**.

9.2 Control functions

NOTE 1 Information on the safety of control functions is given in **JIS B 9705-1**, **JIS B 9961** and **ISO 13849-2**.

NOTE 2 In **9.2**, requirements for the control device itself used to operate the control function are not specified. Examples of such requirements are given in clause **10**.

9.2.1 Start functions

Start functions shall be actuate by energizing the relevant circuit (see **9.2.5.2**).

9.2.2 Stop function

There are three categories of stop functions as follows.

— **Stop category 0**: stopping by immediate removal of power supply to machine actuators (i.e. uncontrolled stop, see **3.56**)

— **Stop category 1**: a controlled stop with power supply available to machine actuators to achieve the stop followed by removal of power supply when the stop is completed (see **3.11**)

— **Stop category 2**: a controlled stop with power supply left available to the machine actuators is after completion of stop

9.2.3 Operating mode

Each machine may have one or more operating modes corresponding to the type and its application. When a hazardous situation may result from the mode selection, unauthorised and/or inadvertent mode selection shall be prevented by suitable means (for example, key operated switch, access code).

Mode selection by itself shall not initiate machine operation. A separate start control other than the mode selection is required.

For each specific operating mode, the relevant safety functions and/or protective measures shall be operated.

The selected operating mode shall be indicated (for example, selected position indicator of mode selector, indicating light, display screen).

9.2.4 Suspension of safety functions and/or protective measures

Where it is necessary to suspend safety functions and/or protective measures (for example, for setup or maintenance purpose), protection shall be ensured according to the following.

— All other operating (control) modes shall be disabled.

— Other relevant means (see **4.11.9** of **JIS B 9700-2**) shall be used. For example, one or more of the following means are used.

- Initiation of operation by a hold-to-run device or by a similar control device.
- A portable control station with an emergency stop device (where appropriate, an enabling device is also provided). Where a portable control station is in use, initiation of movable part of the machine shall only be possible from that control station.
- A cableless control station with a device to command stop functions in accordance with **9.2.7.3** (where appropriate, an enabling device is also provided). Where a cableless control station is in use, initiation of movable part of the machine shall only be possible from that control station.
- Means to limit the speed or the power of motion of machine.
- Means to limit the movable range of machine.

9.2.5 Operation

9.2.5.1 General

The necessary safety functions and/or protective measures [for example, interlock (see **9.3**)] shall be provided for the safe operation.

Measures shall be taken to prevent an unintended action an or unexpected action of the machine after any stopping of the machine (for example, due to lockout, power supply fault, battery replacement, signal loss on cableless control).

Where a machine has more than one control station, measures shall be provided to ensure that the commands from different control stations do not lead to a hazardous situation.

9.2.5.2 Start

The start of an operation shall be possible only when all of the relevant safety functions and/or the protective measures are in place and are operational except for special conditions as described in **9.2.4**.

On those machines (for example, mobile machines) where safety functions and/or protective measures cannot be applied for certain operating conditions, manual operation shall be performed by hold-to-run controls (where appropriate, an enabling devices are also provided).

Suitable interlock functions shall be provided to secure correct sequential starting.

In the case of machines requiring the use of more than one control station to command a start, each of these control stations shall have a separate start control device. The conditions to start shall be as follows.

— All required conditions for machine operation shall be satisfied.

— All start control devices shall be in the off position.

— From the conditions above, all start control devices shall be operated concurrently (see **3.6**).

9.2.5.3 Stop

According to the risk assessment and the functional requirements of the machine (see **4.1**), necessary stop function (one or more) among stop category 0, stop category 1 and stop category 2 shall be provided.

NOTE : When the power supply disconnector (see **5.3**) is used for the stop function, it corresponds to a stop category 0.

Stop functions shall override (interrupt) related start functions (see **9.2.5.2**).

Where necessary, the means to connect protective devices and the interlock devices shall be provided. If such a protective device or interlock is used for a stop of the machine, it may be necessary for that condition to be signalled to the logic circuit of the control system. The reset of the stop function shall not cause any hazardous situation.

Where more than one control station is provided, stop commands from any control station shall be effective when required by the risk assessment of the machine.

9.2.5.4 Emergency operations (emergency stop, emergency switching-off)

9.2.5.4.1 General

This Standard specifies the requirements for the emergency stop and the emergency switching off functions of the emergency operations as shown in Annex E.

These both stop functions shall be started by a single human action.

Once an emergency stop operation (see **10.7**) or an emergency switching off operation (see **10.8**) has actuated, the effect of this command shall be sustained until the stop command is reset. The reset of an emergency stop command and an emergency switching off command shall be possible only by a manual operation at that place where the command has been issued. The reset of stop command only permits restarting and the machine shall not restart by the reset of stop command.

It shall not be possible to restart the machine until all emergency stop commands have been reset. It shall not be possible of power restore of the machine until all emergency switching off commands have been reset.

NOTE : Emergency stop and emergency switching off are complementary protective measures that are not the primary means of risk reduction for hazards (for example, trapping, entanglement, electric shock, burn) at a machine (see **JIS B 9700-1** and **JIS B 9700-2**)].

9.2.5.4.2 Emergency stop

Principles for the design of emergency stop device including the functional aspects are specified in **JIS B 9703**.

The emergency stop shall function either as a stop category 0 or as a stop category 1 (see **9.2.2**). The selection of the stop category of the emergency stop depends on the results of a risk assessment of the machine.

In addition to the requirements for stop (see **9.2.5.3**), the following requirements shall apply to the emergency stop function.

— It shall override all other functions and operations in all modes.

— Power supply to the machine actuators that may cause a hazardous situation shall be either removed immediately (stop category 0) or shall be controlled in such a way to stop the hazardous motion as quickly as practicable (stop category 1) without creating other hazards.

— Reset of emergency stop shall not initiate a restart.

9.2.5.4.3 Emergency switching-off

The functional aspects of emergency switching off are specified in **536.4** of **JIS C 60364-5-53**.

Emergency switching off should be provided for the following cases.

— Protection against direct contact (for example, direct contact with conductor wires, conductor bars, slip-ring assemblies, controlgear in electrical operating areas) is achieved only by placing live parts out of reach or by placing obstacles (see **6.2.6**).

— There is the possibility of other hazards or damage caused by electricity.

Emergency switching off is achieved by switching off the relevant incoming power supply by electromechanical (non-semiconductor) switching devices effecting a stop category 0 of machine actuators connected to this incoming power supply. When it is impossible for a machine to provide stop category 0 due to the nature of the machine, it may be necessary to provide other measures, for example, protection against direct contact so that emergency switching off is not necessary.

9.2.5.5 Monitoring of command actions

Movement or action of a machine or part of a machine that may cause a hazardous situation shall be monitored by providing, for example, the overtravel limiters, overspeed detection of motor, mechanical overload detection or anti-collision devices.

NOTE : On some manually controlled machines, operators provide this monitoring.

9.2.6 Other control functions

9.2.6.1 Hold-to-run controls

NOTE 1 The definition of "hold-to-run control device" is described in **3.26.3** of **JIS B 9700-1** as follows.

"Control device which initiates and maintains hazardous machine functions only as long as the manual control (actuator) is actuated."

Hold-to-run controls shall require continuous operation (hold to push, etc.) of the control device (push button, etc.) for the operation of the machine.

NOTE 2 Hold-to-run control may be achieved by two-hand control devices.

9.2.6.2 Two-hand operation control

NOTE : The detail of "two-hand operation control device" is specified in **JIS B 9712**. The definition of "two-hand operation control device" is described in **3.1** of **JIS B 9712** and **3.26.4** of **JIS B 9700-1** as follows.

"Control device which requires at least simultaneous actuation by both hands in order to initiate and maintain hazardous machine functions, thus providing a protective measure only for the person who actuates it."

Three types of two-hand operation are specified in **JIS B 9712**, the selection of which is determined by the risk assessment. Each type shall provide the following features.

Type I: As follows.

— There are two control devices of concurrent actuation (see **3.6**) by both hands.

— Continuous concurrent operation during the hazardous situation is necessary.

— Machine operation shall stop upon the release of either one or both of the control devices when the hazardous situation is still present.

A two-hand operation control device of Type I is not considered to be suitable for the start of hazardous operation.

Type II: A type I control requiring the release of both control devices before machine operation can be restarted.

Type III: A type II control requiring concurrent actuation of the control devices as follows.

— It shall be necessary to operate two control devices within a certain time limit of each other, not exceeding 0.5 s.

— Where this time limit is exceeded, both control devices shall be released before machine operation can be restarted.

9.2.6.3 Enabling control

NOTE 1 The definition of "enabling device" is described in **3.26.2** of **JIS B 9700-1** as follows.

"Additional manually operated device used in conjunction with a start control and which, when continuously actuated, allows a machine to function."

Enabling control (see also **10.9**) is a manual control function interlock [5] as follows.

a) When the enabled operation is activated, a machine operation is possible by a separate start control.

b) When de-activated,

— A stop function is started.

— Start operation of machine is prevented.

Note [5] For example, the following interlocks are used for the enabling control.

— The enabling control contact turns ON only when the enabling control device is operated.

— The operation of a machine is possible only when the enabling control contact is ON.

Enabling control shall be so arranged as to minimize the possibility of defeating, for example, by requiring the de-activation of the enabling control device before the machine operation may be restarted, and it should not be possible to defeat the enabling function by simple means.

9.2.6.4 Combined start and stop controls

Push-buttons and similar devices which alternately commands the mechanical motion of start and stop shall only be provided for functions which cannot result in a hazardous situation.

9.2.7 Cableless control

9.2.7.1 General

In **9.2.7**, the functional requirements necessary for the control system employing the cableless techniques (for example, radio, infra-red) for transmitting commands and signals between a machine control system and operator control station are specified.

NOTE : Some of these system and application considerations are also applicable to control functions employing the wired serial data communication techniques (for example, coaxial, twisted-pair, optical fibre).

Means shall be provided to readily remove or disconnect the power supply of the operator control station (see also **9.2.7.3**).

Means (for example, key operated switch, access code) shall be provided to prevent unauthorized use of the operator control station, where necessary.

Each operator control station shall carry an unambiguous indication of which machine is intended to be controlled by that operator control station.

9.2.7.2 Control limitation

For the control commands, measures shall be taken to ensure the following.

— The command shall act only on the intended machine.

— The command shall act only on the intended functions.

Measures shall be taken to prevent the machine from responsing to signals other than those from the intended operator control station.

Where necessary, means shall be provided so that the machine can only be controlled from operator control stations in one or more predetermined areas and places.

9.2.7.3 Stop

Cableless operator control stations shall be provided with a stop means which has the operation stop function of machine or the function to stop all the operations that may cause a hazardous situation, and which is separate from other control devices and clearly identifiable. Even though the stop function initiated on the machine can fulfil an emergency stop function, the control device for actuation of this stop function shall not be marked or labelled as an emergency stop.

A machine provided with the cableless control function shall have a means of automatically stopping the machine and of preventing a potentially hazardous operation in the following situations.

— When a stop signal is received

— When a fault is detected in the cableless control system

— When a valid signal (including a signal that the communication is established and maintained) has not been detected within a specified period of time (see Annex B), except when a machine is executing a pre-programmed task taking it outside the range of the cableless control where no hazardous situation can occur.

9.2.7.4 Use of more than one operator control station

Where a machine has more than one operator control station including one or more cableless control stations, measures shall be taken to ensure that only one of the control stations can be enabled at a time. An indication of which the operator control station is in control of the machine shall be provided at suitable places as determined by the risk assessment of the machine.

Exception: A stop command from any one of the control stations shall be effective when required by the risk assessment of the machine.

9.2.7.5 Battery-powered operator control stations

A voltage variation of the battery power supply shall not cause a hazardous situation. If one or more potentially hazardous motions are controlled by using a battery-powered cableless operator control station, a clear warning shall be given to the operator when the battery voltage becomes the specified value or under. Under such a situation, the cableless operator control station shall remain functional long enough for the operator to put the machine into the non-hazardous condition.

9.3 Protective interlocks

9.3.1 Reclosing or resetting of an interlocking safeguard

The reclosing or resetting of an interlocking safeguard shall not start the machine operation which may cause a hazardous situation.

NOTE : Requirements for interlocking guards with a start function (control guard) are specified in **5.3.2.5** of **JIS B 9700-2**.

9.3.2 Exceeding operation limits

Where an operation limit (for example, limit of speed, pressure or position) can be exceeded to lead a hazardous situation, means shall be provided to detect when a predetermined limit is exceeded and initiate an appropriate control.

9.3.3 Operation of auxiliary function

The correct operation of auxiliary functions shall be confirmed by appropriate devices (for example, pressure sensors).

Where the non-operation of a motor or device for an auxiliary function (for example, lubrication, supply of coolant, removal of swarf) may cause a hazardous situation, or cause damage to the machine or to the work in progress, appropriate interlocking shall be provided.

9.3.4 Interlocks between different operations and contrary motions

All contactors, relays and other control devices that control the machine elements and that may cause a hazardous situation when actuated at a time (for example, those initiate contrary motion) shall be interlocked to prevent against such an incorrect operation.

Contactors for reverse control (for example, those controlling the rotation direction of motor) shall be interlocked in such a way that no short-circuit may occur between the circuits in normal operating condition.

Where certain functions on the machine are required to be interrelated for safety or for continuous operation, proper co-ordination shall be ensured by suitable interlocks. For a group of machines working together in a co-ordinated manner and having more than one controlgear, necessary co-ordination shall be made to the operation between the controlgears.

In the state that a failure of a mechanical brake may result in the brake being applied, when the associated machine actuator is energized and a hazardous situation may result, interlocks shall be provided to break the power supply of the machine actuator.

9.3.5 Reverse phase braking

Where the reverse phase braking is employed for a motor, measures shall be provided to prevent the motor starting in the opposite direction at the end of braking where that reversal may cause a hazardous situation or damage to the machine or to the work in progress. For this purpose, a device operating exclusively as a function of time is not permitted.

Control circuits shall be so arranged that the rotation of a motor shaft (for example, manually) shall not cause a hazardous situation.

9.4 Control functions in case of failure

9.4.1 General requirements

Where failures or interferences in the electrical equipment may cause a hazardous situation or damage to the machine or to the work in progress, appropriate measures shall be taken to minimize the probability of the occurrence of such failures or interferences. The required measures and the extent to which they are implemented, either individually or in combination, depend on the level of risk (see **4.1**).

The electrical control circuits shall have an appropriate level of safety performance that has been determined from the risk assessment at the machine. The requirements of **JIS B 9961** and/or **JIS B 9705-1** and **ISO 13849-2** shall apply.

Measures to reduce those risks by the failure of electrical equipment shall include the following, but are not limited to.

— Protective devices on the machine (for example, interlocking guards, trip devices)

— Protective interlocking of the electrical circuit

— Use of proven circuit techniques and components (see **9.4.2.1**)

— Employment of partial or complete redundancy (see **9.4.2.2**) or diversity (see **9.4.2.3**)

— Employment of functional tests (see **9.4.2.4**)

Where memory retention is achieved by the battery power, measures shall be taken to prevent hazardous situations arising from failure or removal of the battery.

Unauthorized or inadvertent memory alteration shall be prevented by, for example, requiring the use of a key, access code or tool.

9.4.2 Measures to minimize risk in case of failure

9.4.2.1 Use of proven circuit techniques and components

The measures shall include the following but are not limited to.

— Connection of control circuit to protective bonding circuit for functional earthing (see **9.4.3.1** and figure 2)

— Connection of control devices in accordance with **9.4.3.1**

— Stopping by de-energizing (see **9.2.2**)

— Switching control for all conductors connecting control circuit and controlled device thereof (see **9.4.3.1**)

— Use of switching devices having direct opening action mechanism (see **JIS C 8201-5-1**)

— Circuit design to reduce the possibility of failures causing undesirable operations

9.4.2.2 Employment of partial or complete redundancy

By employing the partial or complete redundancy, it is possible to minimize the probability that one single failure in the electrical circuit may cause a hazardous situation. Redundancy shall be made to be effective in normal operation (on-line redundant system), or designed as the other circuit so that the redundant system takes over the protective function (off-line redundant system) only where the normal operation fails.

Where off-line redundancy which is not active during the normal operation is employed, suitable measures shall be taken to ensure that those operate when required.

9.4.2.3 Employment of diversity

The use of control circuits having different operation principles or using different types of components or devices can reduce the probability of hazards resulting from faults and/or failures. Examples of diversity are as follows.

— Combined use of normally closed contacts and normally open contacts actuated by interlocking guards

— Use of different types of control circuit components in control circuit

— Combination of electromechanical (non-semiconductor device) and electronic equipment (semiconductor device) so as to be redundant configurations

The combination of electrical system and non-electrical system (for example mechanical, hydraulic, pneumatic) may provide the diversity with redundant function.

9.4.2.4 Employment of functional tests

Execution of functional tests is effective to reduce risks by failures of electrical equipment.

Functional tests shall be executed as the automatic tests by the control system, inspection or tests manually executed by the operator, start-up tests and periodical tests at predetermined interval or a combination thereof, as appropriate (see also **17.2** and **18.6**).

9.4.3 Protection against maloperation due to ground faults, voltage interruptions and loss of circuit continuity

9.4.3.1 Ground faults

Ground faults on any control circuit shall not cause unintentional starting or hazardous motions, or prevent stopping of the machine. Methods to meet these requirements are as follows but are not limited to.

a) **Method a** The power supply of control circuit is fed from transformers for control, and requirements of the following **1**) and **2**) are satisfied.

1) **When power supply of control circuit is earthed** The common conductor of control circuit is connected to the protective bonding circuit at the connecting point of power supply (at one end of secondary side of transformer). All contacts, solid state elements etc., which control an electromagnetic device or other device (for example, a relay, indicator light) are connected between the conductor of switched side and the terminal of the coil or the device. The other terminal of the coil or device (preferably always having the same marking) shall be directly connected to the common conductor of the power supply of control circuit without connecting any switching elements (see figure 3).

Exception: Contacts of protective devices may be connected between the common conductor and the coils when the following conditions are satisfied.

— The circuit is automatically removed in case of ground fault.

— The connection line is very short (for example, in the same enclosure) so that the ground fault unlikely occurs (for example, overload relays).

2) **When power supply of control circuit is not earthed** When the control circuit is fed from a transformer for control but one terminal of power supply for control is not connected to the protective bonding circuit as shown in figure 3, a device that interrupts the circuit automatically in case of ground fault shall be provided (see also **7.2.4**).

b) **Method b** When the power is supplied to the control circuit from a transformer for control with a centre-tapped transformer for control and this centre tap is connected to the protective bonding circuit as shown in figure 4, the overcurrent protective device for switching all conductors of power supply of the control circuit shall be provided.

NOTE 1 In the control circuit in which the centre tap is earthed, the single-phase ground fault may leave 50 % voltage on a relay coil. In this condition, a relay may hold on and result in inability to stop a machine.

NOTE 2 The coil or the control device may be switched on either or both sides (Figure 4 shows the switch on both sides).

c) **Method c When power supply of control circuit is fed without transformer for control** For the following **1**) or **2**), the multi-pole control switch that switches all live conductors shall be used to start or stop those machine functions that may cause a hazardous situation or damage to the machine in the event of unintentional start or failure to stop. Or in the case of **2**), a device that interrupts the circuit automatically in case of ground fault shall be provided.

1) The control circuit is directly connected between the phase conductors of power supply of which one terminal is earthed.

2) The control circuit is connected between phase conductors or between a phase conductor and an unearthed neutral conductor, or between a phase conductor and a neutral conductor earthed through high impedance.

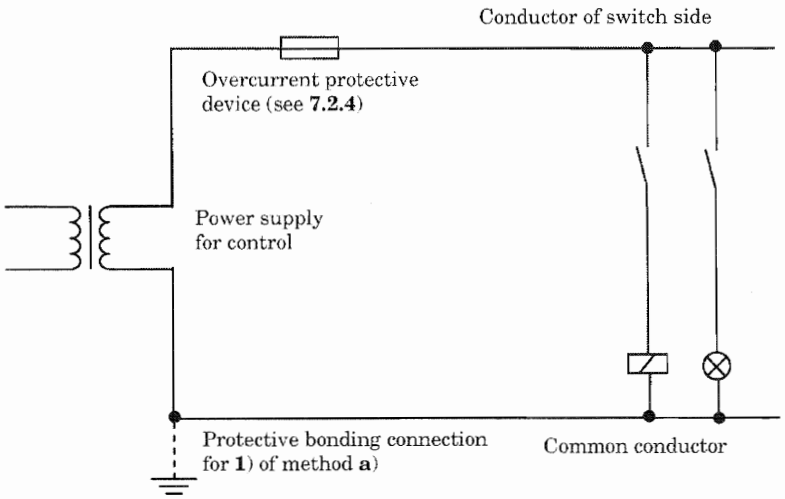


Figure 3 Method a

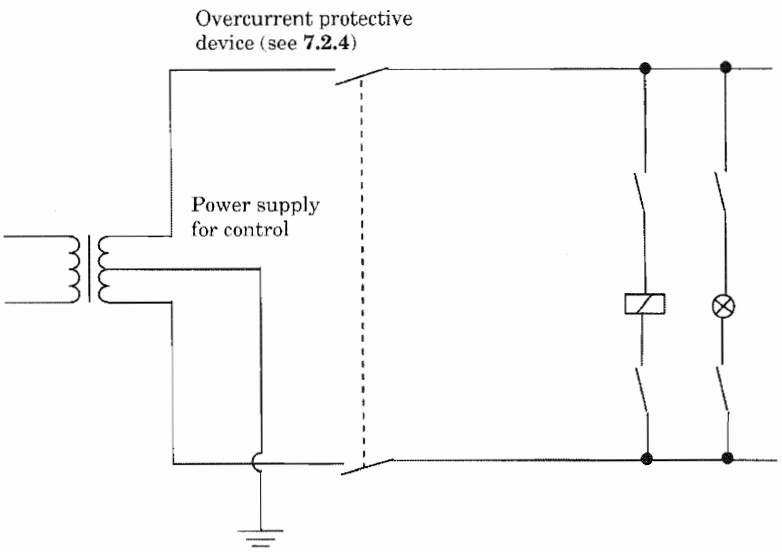


Figure 4 Method b

9.4.3.2 Voltage interruptions

For voltage interruptions, the requirements given in **7.5** shall apply.

Where a memory device is used in the control system, proper functioning in the event of power failure shall be ensured (for example, by using a non-volatile memory) to prevent any loss of memory that may cause a hazardous situation.

9.4.3.3 Loss of circuit continuity

Where the contact failure of the sliding contact used in safety-related control circuits may cause a hazardous situation, appropriate measures shall be taken (for example, duplication of the sliding contacts).

10 Operator interface and machine-mounted control devices

10.1 General

10.1.1 General requirements for control devices

In clause **10**, requirements for control devices mounted outside or partially outside control enclosures are specified.

As far as practicable, those control devices shall be selected, mounted, and identified or coded in accordance with relevant part of **JIS B 9706** series.

The possibility of inadvertent maloperation shall be minimized by, for example, positioning of devices, suitable design and additional protective measures. Particular consideration shall be given to the selection, alignment, programming and use of operator input devices such as the touchscreens, keypads and keyboards for the control of hazardous machine operations. See **JIS C 0447** or **IEC 60447**.

10.1.2 Location and mounting

As far as practicable, the location and mounting of control devices shall satisfy the following.

— Readily accessible for service and maintenance

— Minimize the possibility of damage from activities such as material handling

The actuators of hand-operated control devices shall be selected and mounted as follows.

— 0.6 m or over above the servicing level and within easy reach of normal working position of the operator

— The operator is not placed in a hazardous situation when operating those control devices

The actuators of foot-operated control devices shall be selected and mounted shall satisfy the following.

— Within easy reach of the normal working position of the operator

— The operator is not placed in a hazardous situation when operating those control devices

10.1.3 Protection

The degree of protection (see **JIS C 0920**) together with other appropriate measures shall achieve the following protections.

— The effects of aggressive liquids, vapours, or gases found in the physical environment or used on the machine

— The ingress of contaminants (for example, swarf, dust, particulate matters)

In addition, the control devices for operator interface shall have a minimum degree of protection against direct contact of IPXXD.

10.1.4 Position sensors

Position sensors (for example, position switches, proximity switches) shall be so mounted that they will not be damaged in the event of overtravel of the movable part.

Position sensors in the circuits with safety-related control functions shall have direct opening action mechanism (see **JIS C 8201-5-1**) or shall provide similar reliability (see **9.4.2**).

NOTE : A safety-related control function is the control function intended to maintain the safe condition of the machine or to prevent hazardous situations arising at the machine.

10.1.5 Portable and pendant operator control stations

Portable and pendant operator control stations, and their control devices shall be so selected and located as to minimize the possibility of inadvertent machine operations caused by shocks and the vibrations (for example, drop of control station, collision of obstruction) (see also **4.4.8**).

10.2 Push-buttons

10.2.1 Colours

The push-button actuators shall be colour-coded in accordance with table 2 (see also **9.2** and Annex B).

The colours for the start/on actuators should be white, grey, black or green with a preference for white. Red shall not be used for the start.

Red shall be used for the actuator of emergency stop and emergency switching-off.

The colour for the stop/off actuator should be black, grey or white with a preference for black. Green shall not be used for the stop. Red is permitted, but not recommended to be used near an emergency operation device.

White, grey or black are preferred for push-button actuators that alternately act as start/on and stop/off. Red, yellow or green shall not be used (see **9.2.6**).

White, grey or black are preferred for push-button actuators that actuate operation while they are pressed and stops the operation when they are released (for example, hold-to-run). Red, yellow or green shall not be used.

Reset push-buttons shall be blue, white, grey or black. Where they also act as the stop/off button, the colours white, grey or black are preferred with main preference being black. Green shall not be used.

Where the same colour of white, grey or black is used for various functions (for example, white is used for start/on and stop/off), a complementary means of coding (for example, shape, position, symbol) shall be used for the identification of push-button actuators of which the colour is same but the function is different.

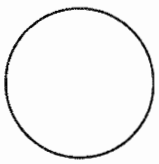
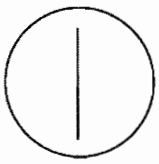
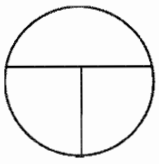
Table 2 Colours and meanings of push-button actuators

Colour	Meaning	Explanation	Examples of application
Red	Emergency	Used in a hazardous situation or emergency operation	Emergency stop Start of emergency function (see also **10.2.1**)
Yellow	Abnormal	Used for operation at occurrence of abnormal	Intervention to suppress abnormal condition Intervention to restart an interrupted automatic cycle
Blue	Mandatory	Used for mandatory operation	Reset function
Green	Normal	Used for start operation under normal condition	(see **10.2.1**)
White	No provision	Used for general start operation of functions except for emergency stop (see NOTE)	Start/on Stop/off ("Start" is preferred.)
Grey			Start/on Stop/off
Black			Start/on Stop/off ("Stop" is preferred.)
NOTE : Where a complementary means of coding (for example shape, position, texture) is used for the identification of push-button actuators, the same colour (white, grey or black) may be used for various functions, for example, white for start/on and for stop/off.			

10.2.2 Markings

In addition to the functional identification given in **16.3**, push-buttons should be marked with the symbols given in table 3 near to or preferably directly on the actuators for the functional identification.

Table 3 Symbol of push-button

Start/on	Stop/off	Start/on • stop/off alternate push-buttons	Push-buttons acting as start/on buttons when pressed and as stop/off buttons when released (e.g. hold-to-run)
IEC 60417-5007 (DB:2002-10)	**IEC 60417-5008** (DB:2002-10)	**IEC 60417-5010** (DB:2002-10)	**IEC 60417-5011** (DB:2002-10)
			

10.3 Indicator lights and displays

10.3.1 General

Indicator lights and the displays serve to give the following types of information.

— Indication to attract the operator's attention or to indicate that a certain action is being required.

Red, yellow, green or blue is normally used in this mode. For indicator lights and displays of flashing type, see **10.3.3**.

— Confirmation of a command or a condition, or completion confirmation of change or transition.

Blue and white are normally used in this mode and green may be used in some cases.

Indicator lights and the displays shall be selected and mounted so as to be visible from the normal position of the operator (see also **JIS B 9706-1**).

For indicator light circuits used for the warning indication, the means shall be provided to check the operability of these lights.

10.3.2 Colours

Unless otherwise agreed between the supplier and the user (see Annex B), indicator lights shall be colour-coded with respect to the condition of the machine in accordance with table 4.

Indicating towers on machines should have the applicable colours in the order of red, yellow, blue, green and white.

Table 4 Condition of machine by colour of indicator light

Colour	Meaning	Explanation (condition of machine)	Required action by operator
Red	Emergency	Hazardous situation	Immediate action for hazardous situation (for example, switching off of power supply of machine, staying clear of the machine by being alert to hazardous situation)
Yellow	Abnormal	Abnormal condition Hazard impending condition	Monitoring and/or intervention (for example, intended function is re-executed)
Blue	Mandatory	Condition which requires an action by the operator	Mandatory action
Green	Normal	Normal condition	Optional
White	Neutral	Other conditions or the case where doubt exists about the use of red, yellow, green, blue	Monitoring

10.3.3 Indicator lights and displays of flashing type

For further distinction or information and especially to give additional emphasis, flashing lights and flashing displays may be provided for the following purposes.

— To attract attention

— To request immediate action

— To indicate a discrepancy between the command and the actual state

— To indicate a change in process (flashing during transition).

Higher frequency flashing lights or flashing displays should be used for higher priority information (see **JIS C 0448** for recommended flashing rates and turn on/turn off period ratios).

Where flashing lights or flashing displays are used for the higher priority information, audible warning devices should also be provided.

10.4 Illuminated push-buttons

Illuminated push-buttons actuator shall be colour-coded in accordance with table 2 and table 4. Where there is difficulty in assigning an appropriate colour, white shall be used. Red for the emergency stop actuator shall not depend on the illumination of its light.

10.5 Rotary control devices

Devices having a rotational member such as a potentiometers and a selector switches shall have means of prevention of rotation of the stationary member. Friction alone is not sufficient.

10.6 Start devices

Actuators used to initiate a start function or the movement of machine elements (for example, slides, spindles, carriers) shall be assembled and mounted so as to minimize inadvertent maloperation. However, mushroom-type actuators may be used for the two-hand control (see also **JIS B 9712**).

10.7 Emergency stop devices

10.7.1 Location of emergency stop devices

Emergency stop devices shall be readily accessible.

Emergency stop devices shall be located at each operator control station and at other locations where an emergency stop operation is required (For the exception in which the stop function is used for the emergency stop, see **9.2.7.3**).

Where the distinction between the emergency stop device in active condition and the emergency stop device in inactive condition (operator control station is in disabled condition) is difficult, the means (for example, information for use) shall be provided to minimise confusion.

10.7.2 Types of emergency stop device

The types of emergency stop device shall be as follows.

— A push-button switch with a palm or mushroom type head

— A pull-cord actuated switch

— A pedal-operated switch without a mechanical guard

The emergency stop device shall have direct opening action mechanism (see Annex K of **JIS C 8201-5-1**).

10.7.3 Colour of actuators

Actuators of emergency stop devices shall be coloured red. The background immediately around the actuator shall be coloured yellow. See also **JIS B 9703**.

10.7.4 Direct operation of the power supply disconnector used for emergency stop

In the following cases, the direct operation of power supply disconnector may be used as the emergency stop function.

— Disconnector is readily accessible to the operator

— Disconnector is of the type given in **5.3.2 a**), **b**), **c**), or **d**)

When also intended for such use, the power supply disconnector shall meet the colour requirements of **10.7.3**.

10.8 Emergency switching off devices

10.8.1 Location of emergency switching off devices

Emergency switching off devices shall be located at the place necessary for that purpose. Normally, those emergency switching off devices shall be located separate from operator control stations. Where it is necessary to provide a control station with an emergency stop device and an emergency switching off device, means shall be provided to avoid confusion between these devices.

NOTE : This can be achieved by, for example, the provision of a break-glass enclosure for the emergency switching off devices.

10.8.2 Type of emergency switching off device

The emergency switching off device shall include the following types.

— A push-button switch with a palm or mushroom type head

— A pull-cord actuated switch

The emergency switching off devices shall have direct opening action mechanism (see Annex K of **JIS C 8201-5-1**).

The push-button switch may be provided in a break-glass enclosure.

10.8.3 Colour of actuators

Actuators of emergency switching off devices shall be coloured red. The background immediately around the actuator shall be coloured yellow.

Where confusion may occur between the emergency stop device and the emergency switching off device, means shall be provided to minimise confusion.

10.8.4 Direct operation of the power supply disconnector used for emergency switching off

Where the power supply disconnector is to be directly operated for emergency switching off, it shall be readily accessible. The actuator should meet the colour requirement of **10.8.3**.

10.9 Enabling control device

When an enabling control device is used as part of a system, the operation is permitted at only one position of the enabling control device actuator. In any other position, operation shall be stopped or prevented.

Enabling control devices shall be selected and assembled so as to minimize the possibility of defeating.

Enabling control devices shall be selected from those having the following features.

— Designed in accordance with ergonomic principles

— Two-position type shall be as follows.

  • Position 1: off-function of the switch (actuator is not operated)

  • Position 2: enabling function (actuator is operated)

— Three-position type shall be as follows.

  • Position 1: off-function of the switch (actuator is not operated)

  • Position 2: enabling function (actuator is operated from position 1 to its mid position)

  • Position 3: off-function of switch (actuator is in over its mid position)

  • When returning from position 3 to position 2, the enabling function is not activated.

  NOTE : The enabling control function is also described in **9.2.6.3**.

11 Controlgear: location, mounting and enclosures

11.1 General requirements

All controlgears (see **3.10**) shall be located and mounted by considering the following.

— Its accessibility and maintenance

— Its protection of controlgear against the external influences or ambient conditions of place where the machine is intended to be operated

— Operation and maintenance of the machine and its associated equipment

11.2 Location and mounting

11.2.1 Accessibility and maintenance

All parts of controlgear shall be placed and oriented so that they can be identified without moving or wiring. For parts that require operation check or replacement, those actions should be possible without dismantling other equipment or parts of the machine (except opening of doors or removing of covers, barriers or obstacles). Terminals (other than those of controlgear components or devices) shall also conform to these requirements.

All controlgears shall be mounted so as to facilitate its operation and maintenance from the front. Where a special tool is necessary to adjust, maintain, or remove a device, such a tool shall be supplied. Where access is required for regular maintenance or adjustment, the relevant devices shall be mounted between 0.4 m and 2.0 m above the

servicing level. Terminals should be 0.2 m or over in height of the servicing level and so located that conductors and the cables can be easily connected to them.

No devices except those for operating, indicating, measuring, and cooling shall be mounted on doors or on the normally removable access covers of enclosures. Where control devices are connected through the plug-in form, their association shall be made clear by type (shape), marking or reference designation, singly or in combination (see **13.4.5**).

More than one plug-in form device handled during normal operation shall have the structure unable to be inserted incorrectly, in the case where it may result in malfunctioning when there is no interchangeability and the mating to the receiving side is incorrect.

Plug/socket combinations handled during the normal operation shall be located and mounted so as to provide unobstructed access.

Where terminals for testing which is connected to the testing equipment are provided, the following shall be satisfied.

— Mounted so as to provide unobstructed access

— Clearly identified to correspond with the documentation (see **17.3**)

— Adequately insulated

— Sufficiently spaced to connect testing equipment

11.2.2 Physical separation or grouping

Non-electrical parts and devices not directly associated with the electrical equipment shall not be located within enclosures which contain controlgear. Devices such as solenoid valves should be separated from the other electrical equipment (for example, in a separate compartment).

Control devices mounted in the same place and connected to the incoming power supply or to both incoming power supply and the control power supply shall be grouped separately from those connected only to the control power supply.

Terminals shall be separated into the following groups.

— Power circuits

— Control circuits

— Other control circuits fed from external power supply (for example, interlock circuit)

The groups may be mounted adjacently, provided that each group can be readily identifiable (for example, by markings, difference in sizes, barriers or colours).

When locating control devices (including interconnection of devices), the clearances and creepage distances determined by the supplier of that device shall be ensured by taking into account the external influences or conditions of the physical environment.

11.2.3 Heating effects

Heat generating components (for example, heat sinks, power resistors) shall be so located that the temperature of each component in the vicinity remains within the permitted value.

11.3 Degree of protection

The protection of controlgear against ingress of solids and liquids shall be adequate taking into account the external influences under which the machine is intended to operate (i.e. the set place and the physical environmental conditions) and shall be sufficient against dust, coolants, swarf, etc.

NOTE 1 Requirements for protection against electric shock are given in clause **6**.

NOTE 2 The degree of protection against ingress of water is specified in **JIS C 0920** (see also Annex JC). Additional protective measures may be necessary against liquids other than water.

Enclosures of controlgear shall have a degree of protection of at least IP22 (see **JIS C 0920**).

Exception: The following **a**) and **b**) are exceptions.

a) Where an electrical operating area is in a protective enclosure for an appropriate degree of protection against the ingress of solids and liquids

b) Where removable current collectors on conductor wire or conductor bar systems are used and IP22 is not achieved, but the means of **6.2.5** are applied.

NOTE 3 Typical application examples of the degree of protection for the enclosure are shown as follows. Depending upon the conditions where the electrical equipment is set, another degree of protection may be appropriate.

— Ventilated enclosure containing only motor starter resistor and other large size equipment IP10

— Ventilated enclosure containing other equipment IP32

— Enclosure used in general industry IP32, IP43, IP54

— Enclosure used in places where cleaned with low-pressure water (hosing) IP55

— Enclosure providing protection against fine dust IP65

— Enclosure containing a slip-ring mechanism IP2X

11.4 Enclosures, doors and openings

Enclosures shall be constructed using materials capable of withstanding the mechanical, electrical and thermal stresses as well as the effects of humidity and other environmental factors that are likely to be encountered in normal use condition.

Fasteners used to secure doors and covers should be of the captive type. Windows for viewing internally mounted indicator shall be of a material suitable to withstand mechanical stress and chemical attack (for example, toughened glass or polycarbonate sheet of 3 mm or over in thickness).

Enclosure doors of controlgear should be 0.9 m or under in width and have vertical hinges with an angle of opening of 95° or over.

The joints or gaskets of doors, lids, covers and enclosures shall withstand the chemical action of the corrosive liquids, vapours or gases used on the machine. The means (gasket, etc.) to maintain the degree of protection of doors, lids or covers that require opening or removal for operation or maintenance shall be as follows.

— Securely mounted to the door, cover or enclosure

— Not deteriorate by removal or replacement of the door or the cover nor impair the degree of protection

Where openings are provided in enclosures (for example, for cable access), means shall be provided to ensure the degree of protection specified for the equipment including those towards the floor or foundation or to other parts of the machine. Opening for cable entries shall be easily re-opened on site. A suitable opening may be provided in the base of enclosures of the machine so that moisture due to condensation can drain away.

There shall be no opening between enclosures containing electrical equipment and compartments containing coolant, lubricating oil or hydraulic oil or those into which oil, other liquid, or dust may penetrate. This requirement does not apply to the electrical devices specifically designed to operate in oil (for example, electromagnetic clutches) nor to the electrical equipment in which coolantes are used.

Where there are holes in an enclosure for mounting purpose, means may be necessary to ensure that the holes do not impair the required protection after mounting.

Equipment (mainly a part, see **3.21**) that may attain a surface temperature sufficient to cause a risk of fire or harmful effect to an enclosure material in normal or abnormal operation shall be as follows.

— Set within an enclosure that will withstand such temperatures as can be generated without risk of fire or deterioration

and

— Located at a sufficient distance from adjacent equipment so as to allow safe dissipation of heat (see **11.2.3**)

or

— Screened by material that can withstand, without risk of fire or deterioration, heat emitted by the equipment

NOTE : A warning label in accordance with **16.2.2** may be necessary.

11.5 Access to controlgear

Doors of passageway and for access to electrical operating areas shall satisfy the following.

— At least 0.7 m in width and 2.1 m in height are ensured.

— Open outwards

— Have a means (for example, panic bolts) to allow opening from inside without use of a key or tool

Enclosures which readily allow a person to fully enter shall be provided with means to allow escape, for example, panic bolts inside the door. The enclosures intended for such access, for example, for resetting, adjusting and maintenance, shall have a clear width of at least 0.7 m and a clear height of at least 2.1 m.

For the following cases, at least 1.0 m in clear width shall be ensured.

— Equipment is likely to be live during access

and

— Conducting parts are exposed

In the case where such parts are present on both sides of the access way, at least 1.5 m in clear width shall be ensured.

NOTE : These dimensions are derived from **JIS B 9713** standards group.

12 Conductors and cables

12.1 General requirements

Conductors and cables shall be selected so as to be suitable for the use condition (for example, voltage, current, protection against electric shock, grouping of cables) and external influences for example, ambient temperature, presence of water or corrosive substances, mechanical stresses (including stresses at installation), fire hazards.

NOTE : For further information, see **CENELEC HD 516 S2** (guide to use of low-voltage cable).

These requirements do not apply to the internal wiring of assemblies that are manufactured and tested in accordance with their relevant Japanese Industrial Standard or **IEC** Standard (for example, **IEC 60439-1**).

12.2 Conductors

In general, conductors shall be of copper. Where aluminium is used, the cross-sectional area shall be 16 mm^2 or over.

To ensure adequate mechanical strength, the cross-sectional area of conductors shall not be under the value shown in table 5. However, conductors with smaller cross-sectional areas or other structures than shown in table 5 may be used provided that adequate mechanical strength is achieved by other means and proper functioning is not impaired.

NOTE : Classification of conductors are given in table D.4.

Class 1 and Class 2 conductors are primarily intended for use between rigid and non-movable parts.

All conductors that are subject to frequent movement (for example, one movement per hour during operation) shall have flexible stranding of Class 5 or Class 6.

NOTE : The conductor class is explained in Annex JE.

Table 5 Minimum cross-sectional area of copper conductor

Unit: mm^2

Installation place	Application	Type of conductor and cable				
		Single core		Multi core		
		Flexible Class 5 or Class 6	Solid single (Class 1) or stranded (Class 2)	Two-core shielded	Two-core not shielded	Three or more-core shielded or not shielded
Wiring outside protective enclosures	Power circuits (fixed)	1.0	1.5	0.75	0.75	0.75
	Power circuits (frequent movements)	1.0	—	0.75	0.75	0.75
	Control circuits	1.0	1.0	0.2	0.5	0.2
	Data communication	—	—	—	—	0.08
Wiring inside enclosures [a)]	Power circuits (fixed)	0.75	0.75	0.75	0.75	0.75
	Control circuits	0.2	0.2	0.2	0.2	0.2
	Data communication	—	—	—	—	0.08
Note [a)] Except special requirements of individual standards, see also **12.1**.						

12.3 Insulation shield

The types of insulation shield includes the following, but are not limited to.

— Polyvinyl chloride (PVC)

— Natural rubber and synthetic rubber

— Silicone rubber (SiR)

— Mineral

— Cross-linked polyethylene (XLPE)

— Ethylene propylene compound (EPR)

Where the insulation shield of conductors and cables (for example, PVC) may constitute hazards due to the propagation of fire or the emission of toxic or corrosive fumes, instructions from the cable supplier should be sought. It is important to give special attention to the integrity of a circuit having a safety-related function.

The insulation shield of cable and conductor shall satisfy the following withstand voltage test.

— Not less than 2 000 V a.c. test voltage for 5 min for operation at voltages over 50 V a.c. or 120 V d.c

or

— 500 V a.c. for 5 min for PELV circuit (See **411.1.5.1** of **JIS C 60364-4-41** for Class III equipment. The definition of Class III equipment is sown in Annex JD).

The mechanical strength and thickness of the insulation shield shall be such that the insulation can not be damaged in operation or during installation, especially for cables pulled into ducts.

12.4 Current-carrying capacity in steady state

The current-carrying capacity depends on several factors, for example, insulation material, number of conductors in a cable, sheath design, installation method, grouping and ambient temperature.

NOTE 1 Detailed information and guidance can be found in **JIS C 60364-5-52** and other standards in Japan or given by the manufacturer.

An example of the current-carrying capacities for PVC insulated conductor between enclosures and individual items of equipment in steady state is given in table 6.

NOTE 2 For specific applications where the correct cable dimensioning depend on the relationship between the duty cycle and the thermal time constant of the cable (for example, starting against high-inertia load, intermittent duty operation), the cable manufacturer should be consulted.

NOTE 3 Typical example of current-carrying capacity of vinyl insulated wire of 600 V according to **JIS C 3307** is shown in Annex JG. In table 6, care shall be taken that the conductor permissible temperature is 70 °C (see **D.3**) and 60 °C in table JG.1.

Table 6 Current-carrying capacity in steady state of PVC insulated copper conductors and cables for different installation method (I_z)

(at ambient temperature 40 °C)

Cross-sectional area mm^2	Installation method (see **D.1.2**)			
	B1	B2	C	E
	Current-carrying capacity of three-phase circuit I_z (A)			
0.75	8.6	8.5	9.8	10.4
1.0	10.3	10.1	11.7	12.4
1.5	13.5	13.1	15.2	16.1
2.5	18.3	17.4	21	22
4	24	23	28	30
6	31	30	36	37
10	44	40	50	52
16	59	54	66	70
25	77	70	84	88
35	96	86	104	110
50	117	103	125	133
70	149	130	160	171
95	180	156	194	207
120	208	179	225	240
For electronic circuit (paired wire)				
0.20	Not applicable	4.3	4.4	4.4
0.5	Not applicable	7.5	7.5	7.8
0.75	Not applicable	9.0	9.5	10

NOTE 1 Values of current-carrying capacity in table 6 are based on the following.

— one symmetrical three-phase a.c. cable of 0.75 mm^2 or over in cross-sectional area

— one paired wire for d.c. control circuit of 0.2 mm^2 to 0.75 mm^2 in cross-sectional area

In the case where more cables/paired wires in which the load current flows are installed, the value in table 6 shall be corrected (see table D.2 or table D.3).

NOTE 2 When the ambient temperature is other than 40 °C, the value shall be corrected (see table D.1).

NOTE 3 The value in this table is not applicable to flexible cables wound on drums (see **12.6.3**).

NOTE 4 For the current-carrying capacity of other cables, see **JIS C 60364-5-52**.

12.5 Voltage drop of conductor and cable

The voltage drop from the point of power supply to the load shall not exceed 5 % of the nominal voltage under the normal operating condition. In order to satisfy this requirement, it may be necessary to use conductors having a larger cross-sectional area than that obtained from table 6.

12.6 Flexible cables

12.6.1 General

Flexible cables shall have Class 5 or Class 6 conductors.

NOTE 1 Class 6 conductors have smaller diameter strands and are more flexible than Class 5 conductors (see table D.4).

Cables subjected to severe duties shall be of adequate structure to protect against the following.

— Abrasion due to mechanical handling and dragging across rough surfaces

— Kinking due to operation without guides

— Stress resulting from guide rollers and forced guiding when wound and re-wound on cable drums

NOTE 2 The durable life of the cable will be reduced where unfavourable operating conditions such as high tensile stress, small bending radii, bending into another plane frequently coincide.

12.6.2 Mechanical rating

The cable handling system of the machine shall be so designed to keep the tensile stress of the conductors as low as practicable during machine operations. Where copper conductors are used, the tensile stress applied to the conductor shall not exceed 15 N/mm^2 of the copper cross-sectional area. Where the application demands exceed the tensile stress limit of 15 N/mm^2, cables with special structure shall be used and the allowed maximal tensile stress should be agreed with the cable manufacturer.

The maximum stress applied to the flexible cables with material other than copper shall be within the cable manufacturer's specification.

NOTE : The following conditions affect the tensile stress of the conductors.

— Acceleration forces

— Speed of motion

— Hanging weight of the cables

— Method of guiding

— Design of cable drum system

12.6.3 Current-carrying capacity of cables wound on drums

Cables to be wound on drums shall be selected with conductors having a cross-sectional area such that, when fully wound on the drum and carrying the normal service load, the maximum permissible conductor temperature is not exceeded.

The permissible current of cables with circular cross-section accommodated on drums should be derated from the maximum current-carrying capacity in free air in accordance with table 7 (see also clause **44** of **IEC 60621-3**).

NOTE : The current-carrying capacity of cables in free air can be obtained from manufacturers' specifications or in relevant standards.

Table 7 Derating factor of permissible current-carrying capacity for cable wound on drum

Drum type	Number of layers of cable				
	Any number	1	2	3	4
Cylindrical ventilated	—	0.85	0.65	0.45	0.35
Radial ventilated	0.85	—	—	—	—
Radial non-ventilated	0.75	—	—	—	—

NOTE 1 A radial type drum is one where spiral layers of the cable are accommodated between closely spaced flanges. If fitted with solid flanges, the drum is described as the non-ventilated type and if the flanges have suitable apertures, as ventilated.

NOTE 2 A ventilated cylinder drum is one where the layers of cable are accommodated between widely spaced flanges and the drum and end flanges have ventilating apertures.

NOTE 3 Discussion on the use of derating factors with the cable and the cable drum manufacturer is recommended. This may result in other factors being used.

12.7 Conductor wires, conductor bars and slip-ring assemblies

12.7.1 Protection against direct contact

Conductor wires, conductor bars and slip-ring assemblies shall be set in such a way that, during normal access to the machine, protection against direct contact is achieved by the application of one of the following protective measures.

— Protection by partial insulation of live parts

or

— Where the above is not practicable, protection by enclosures or barriers of at least IP2X (see **412.2** of **JIS C 60364-4-41**).

Horizontal top surfaces of barriers or enclosures that are readily accessible shall provide a degree of protection of at least IP4X (see **412.2.2** of **JIS C 60364-4-41**).

Where the required degree of protection is not achieved, protection by placing the live parts out of reach in combination with emergency switching off in accordance with **9.2.5.4.3** shall be applied.

Conductor wires and conductor bars shall be so set and/or protected as follows.

— Prevent contact, especially for the unprotected conductor wires and conductor bars, with conductive items such as the cords of pull-cord switches, strain-relief devices and drive chains

— Prevent damage from contacts with a swinging load

12.7.2 Protective conductor circuits

Where conductor wires, conductor bars and slip-ring assemblies are used as part of the protective bonding circuit, they shall not carry current in normal operation. The protective conductor (PE) and the neutral conductor (N) shall use a separate conductor wire, conductor bar or slip-ring, respectively. The continuity of the protective conductor circuit using sliding contacts shall be ensured by taking appropriate measures (for example, duplication of the current collector, continuity monitoring).

12.7.3 Protective conductor current collectors

Protective conductor current collectors shall have a shape or structure so that they are not interchangeable with the other current collectors. Such current collectors shall be of the sliding contact type.

12.7.4 Removable current collectors with a disconnecting function

Removable current collectors with disconnecting function shall be so designed that the protective conductor circuit is interrupted only after the live conductors have been disconnected, and the continuity of the protective conductor circuit is re-established before any live conductor is re-connected (see **8.2.4**).

12.7.5 Clearance in air

The clearances between respective conductors, and between adjacent systems of the conductor wires, conductor bars, slip-ring assemblies and their current collectors shall be suitable for at least a rated impulse voltage of an overvoltage category III in accordance with **JIS C 0664**.

12.7.6 Creepage distances

The creepage distance between respective conductors, and between adjacent systems of conductor wires, conductor bars, slip-ring assemblies and their current collectors shall be suitable for operation in the intended environment, for example, open air (see **JIS C 0664**), inside buildings or protected by enclosures.

In abnormally dusty, moist or corrosive environments, the following creepage distance requirements shall apply.

— Unprotected conductor wires, conductor bars, and slip-ring assemblies shall provide insulators with a minimum creepage distance of 60 mm.

— Enclosed conductor wires, insulated multi-pole conductor bars and insulated individual conductor bars shall have a minimum creepage distance of 30 mm.

The manufacturer's recommendation shall be followed regarding special measures to prevent a gradual reduction in the insulation values due to the unfavourable ambient conditions (for example, deposits of conductive dust, chemical attack).

12.7.7 Conductor system sectioning

Where conductor wires or conductor bars are located so that they can be divided into isolated compartment, suitable design shall be employed to prevent the energization of adjacent compartments by the current collectors themselves.

12.7.8 Structure and installation of conductor wire, conductor bar system and slip-ring assemblies

Conductor wires, conductor bars and slip-ring assemblies in power circuits shall be grouped separately from those in control circuits.

Conductor wires, conductor bars and slip-ring assemblies shall withstand, without damage, the mechanical forces and thermal effects of short-circuit currents.

Removable covers for conductor wire and conductor bar systems set underground or underfloor shall be so designed that they cannot be opened by one person without a tool.

Where more than one conductor bar is set in a common metal enclosure, the individual compartments of the enclosure shall be bonded together and connected to a protective bonding conductor at several points depending upon their length. Metal covers of conductor bars set underground or underfloor shall also be bonded together and connected to a protective bonding conductor.

NOTE : For the protective bonding of metal enclosures or underfloor ducts together with the covers or cover plates, the metal hinges are considered sufficient to ensure continuity.

Underground and underfloor conductor bar ducts shall have drainage facilities.

13 Wiring

13.1 Connections and routing

13.1.1 General requirements

All connections, especially those of the protective bonding circuit, shall be secured against accidental loosening.

The means of connection shall be suitable for the cross-sectional area and nature of the conductors to be connected.

More than one conductor shall not be connected to one terminal, provided that the terminal is designed for the purpose of multiple conductors connection. Only one protective conductor shall always be connected to one terminal.

Connections by soldering shall not be performed on terminals except that are suitable for soldering.

Terminals on terminal blocks shall be plainly marked or labelled to correspond with indications on the drawings.

Where an incorrect electrical connection (for example, arising from replacement of parts) may be a source of risk and it is not practicable to reduce the possibility of incorrect connection by design measures the conductors and/or terminals shall be identified in accordance with **13.2.1**.

The setting of flexible conduits and cables shall be such that liquid shall drain away from the fittings.

Means of retaining conductor strands shall be provided when the stranded wire is connected to the device or the terminal that is not for the stranded wire connection. Solder shall not be used for this purpose.

Shielded conductors shall be so terminated as to prevent fraying of strands and to permit easy disconnection.

Identification tags shall be legible, permanent, and appropriate for the physical environment.

Terminal blocks shall be mounted and wired so that the internal wiring and external wiring do not cross over the terminals (see **JIS C 2811**).

13.1.2 Conductor and cable wiring

Conductors and the cables shall be wired from terminal to terminal without splices or the joints. Connections using plug/socket combinations with suitable protection against accidental disconnection herein are not considered as the joints.

Exception : Where it is impracticable to provide terminals in a junction box, (for example, connections for mobile machine or machines having long flexible cables, cable connections exceeding a length which is not practical to be supplied by the cable manufacturer on one cable drum, connection for repair of cable due to mechanical stresses during installation and operation), splices or joints may be used.

Where it is necessary to connect and disconnect cables and cable assemblies, a sufficient extra length shall be provided for that purpose.

The terminations of cables shall be adequately supported to prevent mechanical stresses at the conductor terminations.

The protective conductor shall be located as close as practicable to the associated live conductors in order to decrease the loop impedance.

13.1.3 Conductors of different circuits

Conductors of different circuits may be installed side by side, may occupy the same duct (for example, conduit, cable trunking system), provided that the arrangement does not impair the proper functioning of respective circuits. Also, conductors in the same multi-core cable may be used. Where those circuits operate at different voltages, the conductors shall be separated by suitable barriers or shall be insulated for the highest voltage to which any conductor within the same duct may be subjected (for example, line to line voltage for unearthed systems and phase to earth voltage for earthed systems).

13.1.4 Connection between pick-up and pick-up converter of an inductive power supply system

The cable between the pick-up and the pick-up converter as specified by the manufacturer of the inductive power supply shall be connected as follows.

— As short as practicable

— Adequately protected against mechanical damage

NOTE : The output of pick-up can be a current source, therefore damage to the cable may result in a high voltage hazard.

13.2 Identification of conductors

13.2.1 General requirements

Each conductor shall be identifiable at each terminal in accordance with the technical documentation (see clause **17**).

Conductors should be identified by number, alphabet, colour (solid or with one or more stripes), a combination of colour and numbers or a combination of colour and alphabet. Arabic numerals shall be used for numbers and Roman (either uppercase or lowercase) shall be used for alphabets.

NOTE : Annex B may be used for the agreement between the supplier and the user regarding a preferred method of identification.

13.2.2 Identification of protective conductor

The protective conductor shall be readily distinguishable by shape, location, marking or colour. When identifying by colour alone, the bicolour combination of green-and-yellow shall be used throughout the length. This bicolour combination of green-and-yellow shall not be used except the protective conductor.

For insulated protective conductors, the bicolour combination of green-and-yellow shall be such that one of the colours covers 30 % or over to and including 70 % of the surface of the protective conductor on any 15 mm length and the other colour covers the remainder of the surface.

Where the protective conductor is easily identifiable by its shape, position or construction (for example, a braided conductor, uninsulated stranded conductor) or where the insulated conductor is not readily accessible, identification by coding throughout its length is not necessary, but the vicinity of terminals or accessible locations shall be clearly identified by the graphical symbol of **IEC 60417-5019** (DB:2002-10) or by the bicolour combination of green-and-yellow.

13.2.3 Identification of the neutral conductor

Where a neutral conductor is identified by colour alone, the colour shall be blue. In order to avoid the confusion with other colours, it is recommended that light blue is used (see **3.2.2** of **IEC 60446**). Where the selected colour is the sole identification of the neutral conductor, that colour shall not be used for identifying any other conductor where confusion is possible.

Where identification by colour is used, bare conductors used as neutral conductors shall be coloured by a stripe of 15 mm to 100 mm wide in each compartment or unit and at each accessible location, or coloured throughout their length.

13.2.4 Identification of conductor by colour

Where the colour-coding is used for the identification of conductors other than the protective conductor (see **13.2.2**) and the neutral conductor (see **13.2.3**), the following colours may be used.

Black, brown, red, orange, yellow, green, blue (including light blue), violet, grey, white, pink and turquoise

NOTE : This list of colours is derived from **IEC 60757**.

Where colour is used for identification, the colour should be used throughout the length of the conductor of the insulation shield or marked at regular intervals as well as at terminals or accessible places.

For safety reasons, green or yellow should not be used where the confusion with the bicolour combination of green-and-yellow may occur (see **13.2.2**).

Colour identification using combinations of those colours listed above may be used provided there can be no confusion and that green or yellow is not used except in the bicolour combination of green-and-yellow.

Where the colour-coding is used for identification of conductors, they should be colour-coded as follows.

— Black: a.c. power circuits and d.c. power circuits

— Red: a.c. control circuits

— Blue: d.c. control circuits

— Orange: excepted circuits specified in **5.3.5**

Exception: The following cases are not necessarily in accordance with the recommendations above.

— No conductor with the insulation shield of recommended colour is used

or

— Multi-core cable is used; however the bicolour combination of green-and-yellow shall not be used.

13.3 Wiring inside enclosures

Conductors inside enclosures shall be anchored when it is necessary to support them in place. For the non-metallic ducts, that made with a flame-retardant insulating material shall be used (see **JIS C 3665** series).

Electrical equipment mounted inside enclosures should be designed and manufactured in such a way as to permit the modification of the wiring from the front of the enclosure (see also **11.2.1**). Where that is not practicable and the control devices are connected from the rear of the enclosures, access doors or the swingout panels shall be provided.

Connections to devices mounted on doors or to other movable parts shall be made using the flexible conductors in accordance with **12.2** and **12.6** to allow for the frequent movement of the movable part. This conductors shall be anchored to the fixed part and to the movable part independently of the electrical connection (see also **8.2.3** and **11.2.1**).

Conductors and cables not contained in ducts shall adequately be supported.

Terminal blocks or plug/socket combinations shall be used for control wiring that extends beyond the enclosure. For the plug/socket combinations, see also **13.4.5** and **13.4.6**.

Cables for power circuit and cables of measuring circuits may be directly connected to the terminals for connection of the devices.

13.4 Wiring outside enclosures

13.4.1 General requirements

The means of introduction of cables or ducts with their individual glands, bushings, etc., into an enclosure shall ensure that the degree of protection is not reduced (see **11.3**).

13.4.2 External ducts

Conductors and their connecting parts of external to the electrical equipment enclosure shall be contained in suitable ducts specified in **13.5** (for example, conduit or cable trunking systems), except for suitably protected cables may be wired without enclosed in ducts. When not contained in ducts, open cable trays or the cable support

means may be used, if necessary; or otherwise, may not be used. A dedicated cable for devices such as position switches or proximity switches need not be enclosed in a duct when the cable is suitable for the purpose, sufficiently short, and so located or protected that the risk of damage is minimized.

Mounting instruments used with ducts or multi-core cable shall be suitable for the physical environment.

Flexible conduit or flexible multi-core cable shall be used where it is necessary to employ flexible connections to pendant control stations. The weight of the pendant control stations shall be supported by means other than the flexible conduit or the flexible multi-core cable, except where the conduit or cable is specifically designed for that purpose.

13.4.3 Connection to movable part of the machine

Connections to frequently moving movable parts, shall be made using conductors conforming to **12.2** and **12.6**. Flexible cable and flexible conduit shall be so mounted as to avoid excessive flexing and straining, particularly at mounting part and fitting part.

Cables used for the movable part shall be supported in such a way that there is no mechanical strain on the connection points nor any excessive flexing. When this is achieved by being supported in a loop, it shall have sufficient length to provide for a bending radius of at least 10 times the diameter of the cable.

Flexible cables of machines shall be so installed or protected as to minimize the possibility of damage to the sheath due to factors that include the following cable use or potential abuse.

— Being run over by the machine itself

— Being run over by vehicles or other machines

— Coming into contact with the machine structure during movements

— Running in and out of cable baskets or wind on or off cable drums

— Acceleration forces and wind forces on festoon systems or suspended cables

— Excessive rubbing by cable container

— Exposure to excessive radiated heat

The cable sheath shall be resistant to the normal wear expected from movement and to the effects of environmental contaminants (for example, oil, water, coolants, dust).

Where the cable subject to movement is located close to the movable part of machine, measures shall be taken to maintain a space of 25 mm or over between the movable parts and the cables. Where that distance is not practicable, fixed barriers shall be provided between the cables and the movable parts of the machine.

The cable handling system shall be so designed that twist angles of cable around the axis do not exceed 5° to avoid torsion in the cable in the following case.

— Being wound on and off cable drums

and

— Approaching and leaving cable guidance devices

Measures shall be taken to ensure that at least two turns of flexible cables always remain on a drum.

Devices for guide and devices for transportation of a flexible cable shall be so designed that the bending radius shall be the value given in table 8 or over, unless otherwise agreed with the cable manufacturer, taking into account the permissible tension and the expected metal fatigue.

Table 8 Minimum permissible bending radii for the forced guiding of flexible cables

Application	Cable diameter or thickness of flat cable d (mm)		
	$d \leq 8$	$8 < d \leq 20$	$d > 20$
Cable drum	$6d$	$6d$	$8d$
Guide roller	$6d$	$8d$	$8d$
Festoon system	$6d$	$6d$	$8d$
Others	$6d$	$6d$	$8d$

The straight part between two bends shall be at least 20 times the diameter of the cable.

Where the flexible conduit is adjacent to the movable parts of machine, the structure and supporting means of conduit shall prevent damage to the flexible conduit under all conditions of operation.

Flexible conduits shall not be used for connections subject to rapid or frequent movements, except when specially designed for that purpose.

13.4.4 Interconnection of devices on the machine

Where more than one on-board switching device (for example, position sensors, push-buttons) are connected in series or in parallel, the terminal for testing should be provided intermediate connections between those devices. Such terminals shall be conveniently placed for testing, adequately protected, and shown on the relevant diagrams.

13.4.5 Connection by plug/socket combination

Where plug/socket combinations are used for the connection, the corresponding item among the following requirements of **a**) to **e**) shall be applied.

Exception: These requirements do not apply to fixed plug/socket combinations (without flexible cable) for connecting components inside an enclosure, or a plug/socket combination for connecting components to a bus system.

a) When mounted correctly in accordance with **f**), plug/socket combinations shall be of such a type as to prevent unintentional contact with the live parts at any time including during insertion or removal of the plug. The degree of protection shall be at least IPXXB. This requirement is not applicable to PELV circuit.

b) When using the power supply of TN earthing system or TT earthing system, the contact for protective bonding (contact for earthing) shall make a contact firstly at plug-on and break lastly at plug-off out of other contacts.

c) Plug/socket combinations intended to be connected or disconnected under loaded conditions shall have sufficient breaking capacity. Where the plug/socket combination is rated at 30 A or over, it shall be interlocked with a switching device so that the connection and disconnection is possible only when the switching device is in the OFF position.

d) Plug/socket combinations rated at over 16 A shall be of a connection retaining type to prevent unintended or accidental disconnection.

e) Where an unintended or accidental disconnection of plug/socket combinations may cause a hazardous situation, they shall have a means to retain connections.

The mounting of plug/socket combinations shall satisfy the following requirements of **f)** to **k)**.

f) The component which remains live after disconnection shall have a degree of protection of at least IP2X or IPXXB by taking into account the required clearance in air and creepage distances. This requirement is not applicable to PELV circuits.

g) Metallic housings of plug/socket combinations shall be connected to the protective bonding circuit. This requirement is not applicable to PELV circuits.

h) Plug/socket combinations intended to carry power loads but not to be disconnected during load conditions shall be of the connection retaining type to prevent unintended or accidental disconnection and shall be clearly marked that they are not intended to be disconnected under load.

i) Where more than one plug/socket combination is provided in the same electrical equipment, the associated mating shall be clearly identifiable. Mechanical measures should be used to prevent incorrect insertion.

j) Plug/socket combinations used in control circuits shall satisfy the applicable requirements of **IEC 61984**.

Exception: The plug/socket combination specified in **JIS C 8285-1** may be used in the control circuit provided that item **k)** is satisfied.

k) Plug/socket combinations intended for household and similar general purposes shall not be used for control circuits. In plug/socket combinations specified in **JIS C 8285-1**, only those contacts which shall be used for the control circuit which are intended for those purpose.

Exception: The requirements of item **k)** do not apply to control functions using high frequency signals on the power supply.

13.4.6 Dismantling for shipment

Where it is necessary that wiring be disconnected for shipment, terminal blocks or plug/socket combinations shall be provided for the disconnected points. Such terminal blocks shall be suitably enclosed and plug/socket combinations shall be protected from the physical environment during transportation and storage.

13.4.7 Additional conductors

For maintenance or repair, additional conductors should be wired. When spare conductors are provided, they shall be connected to spare terminals or insulted in such a manner as to prevent contact with live parts.

13.5 Ducts, connection boxes and other boxes

13.5.1 General requirements

Ducts shall provide a degree of protection suitable for the application (see **JIS C 0920**).

All sharp edges, flash, burrs, rough surfaces, or threads with which the insulation of the conductor may come in contact shall be removed from ducts and its fittings. Where necessary, additional protection consisting of a flame-retardant, oil-resistant insulating material shall be provided to protect the conductor insulation.

Drain holes of 6 mm in diameter are permitted in cable trunking systems, connection boxes and other wiring boxes that may be subject to accumulations of oil or moisture.

In order to prevent confusion of conduits with piping for oil, air, or water, conduits should be either physically separated or suitably identified.

Ducts and the cable trays shall be rigidly supported and located at a sufficient distance from the movable part and in such a manner so as to minimize the possibility of damage or wear. In areas where passageway is required, the ducts and the cable trays shall be set at least 2 m above the working surface.

Ducts shall be provided only for the mechanical protection (see **8.2.3** for requirements for connection to the protective bonding circuit).

Cable trays partially covered should not be considered as ducts or cable trunking systems (see **13.5.6**), and the cables used shall be of a type suitable for installation with or without the use of open cable trays or cable support means.

13.5.2 Percentage fill of ducts

Consideration of the percentage fill of ducts should be based on the straightness and length of the duct and the flexibility of the conductors. The dimensions and arrangement of the ducts should be such that the conductors and cables be easily inserted.

13.5.3 Rigid metal conduit and fittings

Rigid metal conduit and fittings shall be of galvanized steel or of a corrosion-resistant material suitable for the conditions. The use of dissimilar metals in contact that can cause galvanic action should be avoided.

Conduits shall be securely held in place and supported at each end.

Fittings (joints, parts for mounting, etc.) shall be compatible with the conduit and appropriate for the application. Fittings shall be threaded unless structural difficulties prevent assembly. Where threadless fittings are used, the conduit shall be securely fastened to the equipment.

Conduit bends shall be made in such a manner that the conduit shall not be damaged and the internal diameter of the conduit shall not be effectively reduced.

13.5.4 Flexible metal conduit and fittings

A flexible metal conduit shall be constructed with a flexible metal pipe or woven wire sheath, and shall be suitable for the expected physical environment.

Fittings shall be compatible with the conduit and appropriate for the application.

13.5.5 Flexible non-metallic conduit and fittings

Flexible non-metallic conduit shall be resistant to kinking and shall have physical characteristics equivalent to those of the sheath of multi-core cables.

The conduit shall be suitable for use in the expected physical environment.

Fittings shall be compatible with the conduit and appropriate for the application.

13.5.6 Cable trunking systems

Cable trunking systems external to enclosures shall be rigidly supported and clear of all movable parts or contaminating parts of the machine.

Covers shall be shaped to overlap the sides. Gaskets may be used. Covers shall be mounted to cable trunking systems by suitable means. On horizontal cable trunking systems, the cover shall not be provided on the bottom unless specifically designed for that purpose.

NOTE : Requirements for cable trunking systems and ducts of the electrical facility are given in the **IEC 61084**.

Where the cable trunking system is mounted in sections, the joints between sections shall fit tightly, but need not be gasketed.

The only openings permitted shall be those required for wiring or for drainage. Cable trunking systems shall not have opened but unused knockouts.

13.5.7 Compartments and cable trunking systems in machine

When using compartments or cable trunking systems within the column or base of a machine to cover conductors, the compartment or the cable trunking system shall be isolated from coolant or oil reservoir and entirely enclosed. Conductors in enclosed compartments and cable trunking systems shall be so anchored and located that they are not subject to damage.

13.5.8 Connection boxes and other boxes

Connection boxes and other boxes for wiring shall be accessible for maintenance. These boxes shall provide protection against the ingress of solid bodies and liquids, taking into account the external influence under which the machine is intended to operate (see **11.3**).

These boxes shall not have opened and unused knockouts and shall be so constructed as to prevent the ingress of materials such as dust, lint, oil, and coolant.

13.5.9 Motor connection boxes

Motor connection boxes shall enclose only connection parts to the motor and motor-mounted devices (for example, brakes, temperature sensors, plugging switches, tachometer generators).

14 Electric motors and associated equipment

14.1 General requirements

Electric motors should conform to the relevant parts of **JIS C 4034-1**, **JIS C 4034-5**, **JIS C 4203**, **JIS C 4210** or **IEC 60034** series.

NOTE : Part of the contents of **IEC 60034** series may or may not overlap those of **JIS C 4034-1**, **JIS C 4034-5**, **JIS C 4203** and **JIS C 4210**.

The protection requirements for motors and associated equipment are given in **7.2** for the overcurrent, in **7.3** for the overload and in **7.6** for the overspeed.

As most controllers do not break the power supply to a motor when it is at rest, care shall be taken to ensure compliance with the requirements of **5.3**, **5.4**, **5.5**, **7.5**, **7.6** and **9.4**. Motor control equipment shall be located and mounted in accordance with clause **11**.

14.2 Motor enclosures

Motor enclosures should be chosen from those specified in **JIS C 4034-5**.

The degree of protection of the motor enclosure shall satisfy at least IP23 (see **JIS C 0920**) for all motors. More severe requirements may be needed depending on the application and the physical environment (see **4.4**). Motors incorporated in the machine shall be so mounted that they are adequately protected from the mechanical damage.

14.3 Dimensions of motor

As far as practicable, the dimensions of motors shall conform to those given in **JIS C 4203**, **JIS C 4210**, **JIS C 4212** or **IEC 60072** series.

NOTE : Part of the contents of **IEC 60072** series may or may not overlap those of **JIS C 4203**, **JIS C 4210**, and **JIS C 4212**.

14.4 Mounting and compartments for motor

Each motor and associated couplings, belts, pulleys and chains shall be so mounted that they are adequately protected and are easily accessible for inspection, maintenance, adjustment, alignment, lubrication and replacement. The motor mounting arrangement shall be such that all motor hold-down fixtures can be removed and all terminal boxes are accessible.

Motors shall be so mounted that proper cooling is ensured and the temperature rise remains within the permissible limits of the insulation class (see **JIS C 4034-1**).

Compartments for motor should be clean and dry as practicable as possible, and it shall be ventilated directly to the exterior of the machine when required. The vents shall be such that ingress of swarf, dust, or water spray is within the permissible level.

There shall be no opening between the compartment for motor and any other compartment that does not meet the requirements of compartment for motor. Where a conduit or pipe is run into the compartment for motor from another compartment which does not meet the requirements of compartment for motor, any clearance around the conduit or pipe shall be sealed.

14.5 Criteria for motor selection

The characteristics of motors and associated equipment shall be so selected as to conforming to the anticipated application and physical environmental conditions (see **4.4**). In this respect, the following points shall be considered.

— Type of motor

— Type of duty cycle (see **JIS C 4034-1**)

— Fixed speed operation or variable speed operation (and the consequent effect by variation of ventilation)

— Mechanical vibration

— Type of motor control

— Influence of harmonic spectrum of voltage/current supplied to motor (particularly when supplied from static converter) on the temperature rise

— Starting method and the possible influence of the inrush current on the equipment operation of other users of same power supply. Special cautions specified by the power company shall be considered.

— Variation of counter-torque load with time and speed

— Effect of loads with large inertia

— Effect of constant torque or constant output operation

— Need of inductive reactors between motor and converter

14.6 Protective devices for mechanical brakes

When the overload and overcurrent protective devices for mechanical brake actuator is operated, the associated machine actuators shall also be simultaneously de-energized (released).

NOTE : Associated machine actuators refer to all associated actuators in the case where more than one actuator concerns to one movement.

15 Accessories and lighting

15.1 Socket-outlets for accessories

Where the machine or its associated equipment is provided with socket-outlets intended to be used for accessory equipment (for example, hand-held power tools, testing equipment), the following shall apply.

— The socket-outlets should conform to **JIS C 8285-1**. Where that is not practicable, the voltage and the current ratings should be clearly marked.

— The continuity of protective bonding circuit to the socket-outlet shall be ensured except where protection is provided by PELV.

— All unearthed conductors connected to the socket-outlet shall be protected against overcurrent and, when required, against overload in accordance with **7.2** and **7.3** separately from the protection of other circuits.

— Where the power supply to the socket-outlet is not disconnected by the power supply disconnector for the machine or part of the machine, the requirements of **5.3.5** shall apply.

NOTE 1 See also Annex B.

NOTE 2 The socket-outlet circuits may be provided with the residual current protective devices (RCD).

15.2 Local lighting of the machine and equipment

15.2.1 General

Connections to the protective bonding circuit of local lighting circuit shall be in accordance with **8.2.2**.

The switch shall not be integrated in the lampholder or in the flexible connecting cords.

Stroboscopic effect from lights shall be avoided by selecting the appropriate luminaries.

Where the fixed lighting is provided inside an enclosure, electromagnetic compatibility should be taken into account using the principles shown in **4.4.2**.

15.2.2 Power supply

The nominal voltage of the local lighting circuit shall be 250 V or under between conductors. A voltage of 50 V or under between conductors is recommended.

Lighting circuits shall be supplied from one of the following power supply (see also **7.2.6**)

— A dedicated insulted transformer for lighting connected to the load side of incoming power supply disconnector. Overcurrent protection shall be provided in the secondary side circuit of transformer.

— A dedicated insulted transformer for lighting connected to the power supply line side of incoming power supply disconnector. This power supply shall be used for the lighting circuit for maintenance in control enclosures only. Overcurrent protection shall be provided in the secondary side circuit of transformer dedicated for lighting (see **5.3.5** and **13.1.3**).

— A circuit in the machine with dedicated overcurrent protection

— An isolating transformer connected to the power supply line side of incoming power supply disconnector provided with a switching means for primary side of dedicated local lighting (see **5.3.5**) and the overcurrent protection for secondary side, and mounted within the control enclosure adjacent to the power supply disconnector (see also **13.1.3**)

— Power supply for lighting externally supplied (for example, power supply of factory lighting). This shall be used for the lighting in control enclosures only and for the machine work light where their total power rating is under 3 kW.

Exception: For the fixed lighting which is out of reach of operators during normal operations, the specification of **15.2.2** is not applicable.

15.2.3 Protection

Local lighting circuits shall be protected in accordance with **7.2.6**.

15.2.4 Mounting instrument

The adjustable mounting instrument for lighting shall be suitable for the physical environment.

The lampholders shall satisfy the following.

— Conforming to the relevant Japanese Industrial Standard and **IEC** Standard

— Constructed with an insulating material protecting the lamp cap so as to prevent unintentional contact when the lamp cap is adjusted (moved).

The reflector shall be supported by a bracket and not by the lamp holder.

Exception: For the fixed lighting instrument which is out of reach of the operator during normal operation, the specification of **15.2.4** is not applicable.

16 Marking, warning signs and reference designations

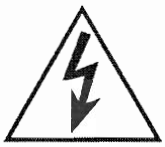
16.1 General

Warning signs, nameplates, markings and identification plates shall be of sufficient durability to withstand the physical environment of equipment.

16.2 Warning signs

16.2.1 Electric shock hazard

Enclosures that do not otherwise clearly show that they contain electrical equipment having a risk of electric shock shall be marked with the graphical symbol **IEC 60417-5036** (DB:2002-10).



This warning sign shall be plainly visible on the door or the cover of enclosure; however, it may be omitted in the following cases [see also **6.2.2 b**)].

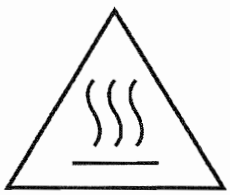
— An enclosure equipped with a power supply disconnector

— An operator interface equipment or control station

— A single device with its own enclosure (for example, position sensor).

16.2.2 High temperature hazard

Where the risk assessment shows the need to warn against the possibility of hazardous surface temperatures of the electrical equipment, the graphical symbol **IEC 60417-5041** (DB:2002-10) shall be used.



NOTE : For electrical installations in buildings, this measure is specified in **423** and table 42A of **JIS C 60364-4-42**.

16.3 Functional indication

Control devices, indicators and displays (particularly, those related to safety) shall be clearly and durably marked with regard to their functions either on the device itself

or adjacent to it. Such markings should be agreed between the user and the supplier of the equipment (see Annex B). Preference should be given to the use of symbols specified in **IEC 60417** (DB:2002) and **ISO 7000**.

16.4 Marking of equipment

Equipment (for example, controlgear assemblies) shall be legibly and durably marked in a way that is plainly visible after the installation of equipment. A nameplate which shows the following information shall be attached to the enclosure adjacent to each inlet of incoming power supply.

— Name or trademark of supplier

— Certification mark, when required

— Serial number, where applicable

— Rated voltage, number of phases and frequency (if a.c.) for each power supply, and full-load current

— Short-circuit rating of the equipment (for example, short-circuit breaking capacity)

— Main document number (see **IEC 62023**).

The full-load current shown on the nameplate shall be the load current or over for all motors and other equipment that can be operated at the same time under normal condition.

Where only a single motor controller is used in a machine, that information may be provided on the machine nameplate in a manner that it is plainly visible.

16.5 Reference designations

All enclosures, assemblies, control devices and components shall clearly be identified with the same reference designation as shown in the technical documentation.

17 Technical documentation

17.1 General

The information necessary for installation, operation, and maintenance of the electrical equipment of a machine shall be provided (supplied) in the forms, for example, of drawings, connection diagrams, charts, tables and instruction manuals. The content and amount of information to be provided may vary with the complexity of the electrical equipment. For very simple equipment, the relevant information may be contained in one document, provided that the document shows all the devices of the electrical equipment and enables the connections to the power supply to be made.

NOTE : The technical documentation provided with components of electrical equipment may form part of the documentation of the electrical equipment of machine.

17.2 Information to be provided

The information (technical documentation) provided (supplied) with the electrical equipment shall include the following.

a) A main document (parts list or documents list)

b) Complementary documents including the following

1) A clear, comprehensive explanation of the equipment, installation and mounting, and the power supply connection

2) Power supply specification

3) Information on the physical environment (for example, lighting, vibration, noise levels, contaminants in air), if required

4) Overview diagram (block diagram), if required

5) Circuit diagram

6) Necessary information regarding the following

— Programming necessary for use of the equipment

— Operation sequence

— Frequency of inspection

— Frequency and method of functional testing

— Guidance on adjustment, maintenance and repair, particularly of the protective devices and protective circuits

— Recommended spare parts list

— List of supplied tools

7) An explanation (including interconnection diagrams) of safeguards, interlocking functions and interlocking of guards, particularly for machines operating in a co-ordinated manner is necessary

8) An explanation of the safeguarding and resetting means provided where it is necessary to reset the safeguarding (for example, for manual programming, verification of programming) (see **9.2.4**)

9) Instructions on the procedures for securing safety for maintenance service (see also **17.8**)

10) Information on handling, transportation and storage

11) Information regarding load currents, starting peak currents and permissible voltage drops (if necessary)

12) Information on the residual risk due to the protection measures adopted (executed), explanation of whether any particular training is required and specification of any necessary personal protective equipment

17.3 Requirements for all documents

Unless otherwise agreed between the manufacturer and the user of the electrical equipment on the documents and the like, the following shall apply.

— The documents and the like shall be prepared in accordance with relevant parts of **JIS C 1082** series

— Reference designations shall conform to relevant parts of **JIS C 0452** series

— Instruction manual shall conform to **JIS C 0457**

— Parts list (when used) shall conform to Class B of **JIS C 0453**

NOTE : See clause **13** of **B.1**.

For the reference on different documents, the supplier shall adopt one of the following.

— Where the documents and the like consist of a small number of documents (for example, under 5), each of the documents shall carry as a cross-reference the document numbers of all other documents related to the electrical equipment

— Document numbers and document titles of all documents shall be listed in a drawing or document list of the single level main documents (see **IEC 62023**) (for the single level document construction).

— Document numbers and document titles of all documents belonging to a certain level shall be listed in a drawing or document list of the same level (see **IEC 62023**) (for the multi level document construction).

17.4 Installation documents

The installation documents shall give all information necessary for the preliminary service of setting-up the machine (including commissioning). For the complex electrical equipment, the detail assembly diagram may be necessary.

The recommended location, type and cross-sectional areas of the power supply cables to be installed shall be clearly indicated.

The data necessary for the selection of type, characteristics, rated currents, and setting values of the overcurrent protective devices for the power supply conductor feeding to the electrical equipment of the machine shall be indicated (see **7.2.2**).

Where necessary, the size, purpose, and location of any ducts to be set in the foundation that are to be prepared by the user shall be indicated in detail (see Annex B).

When ducts, cable trays or cable supports between the machine and the associated equipment that are to be prepared by the user, the size, type, and purpose thereof shall be described in detail (see Annex B).

When the space is required for the removal or servicing of the electrical equipment, it shall be indicated on the diagram.

NOTE 1 An example of installation document is shown in **JIS C 1082-4**.

In addition, where necessary, an interconnection diagram or the interconnection table shall be included in the installation document. That diagram or table shall give full information about all external connections. Where the electrical equipment is operated by more than one power supply, the interconnection diagram or the interconnection table shall indicate the wire modifications or interconnections required for the use of each power supply.

NOTE 2 Examples of interconnection diagram and interconnection table are shown in **JIS C 1082-3**.

17.5 Overview diagrams and function diagrams

Where it is necessary to facilitate the understanding of the principles of operation, an overview diagram shall be included in the technical documentation to be supplied.

An overview diagram symbolically represents the electrical equipment together with its functional interrelationships without necessarily showing all of the interconnections.

NOTE 1 Examples of overview diagrams are shown in **JIS C 1082** series.

Function diagrams may be provided as either part of or in addition to the overview diagram.

NOTE 2 Examples of function diagrams are shown in **JIS C 1082-2**.

17.6 Circuit diagrams

A circuit diagram shall be included in the technical documentation to be supplied. The circuit diagram shall show the electrical circuits on the machine and its associated electrical equipment. Any graphical symbol not shown in **JIS C 0617** series shall be separately shown and explained on the diagram or the accompanying documents thereof. The symbols and identification of components and devices shall be consistent throughout all documents and on the machine.

Where necessary, a diagram showing the interconnecting terminals between units shall be provided. This diagram may be used in conjunction with the circuit diagram for simplification. This diagram should contain a reference to the detailed circuit diagram of each unit.

Symbols of switch (contact) shall be shown on the electric circuit diagrams with all supply sources turned off (for example, electricity, air, water, lubricant) and with the machine and its electrical equipment ready for a normal start.

Conductors shall be identified in accordance with **13.2**.

Circuits shall be shown in such a way as to facilitate the understanding of their function as well as the maintenance and fault location. Characteristics relating to the function of the control devices and the components not evident from their symbolic representation shall be included on the circuit diagrams literally or the like adjacent to the symbol or referenced to a footnote.

17.7 Operating manual

The technical documentation shall contain an operating manual detailing proper procedures for set-up and use of the electrical equipment. Particular attention should be given to the safety measures provided.

Where the operation of the equipment is programmable, detailed information on the programming methods, equipment required for programming, verification of program, and additional safety procedures (where required) shall be indicated.

17.8 Maintenance manual

The technical documentation shall contain a maintenance manual detailing proper procedures for adjustment, care, preventive inspection and repair. Recommendations on maintenance/care intervals and the records should be included in this manual.

Where the verification methods of proper operation are provided (for example, software testing program), the use of those methods shall be indicated in detail.

17.9 Parts list

The parts list shall contain, as a minimum, information necessary for ordering spare parts or replacement parts (for example, components, devices, software, testing equipment, technical documentation) required for preventive maintenance or corrective maintenance including those that are recommended to be carried in stock by the user of the equipment.

18 Verification

18.1 General

This Standard specifies the general requirements for the electrical equipment of machines.

The extent of verification will be given in the dedicated product standard for a particular machine. Where there is no dedicated product standard for the machine, the verifications of following **a**), **b**) and **f**) shall always be performed. Furthermore, one or more of the items **c**), **d**) and **e**) may be included.

a) Verification that the electrical equipment conforms to its technical documentation

b) In the case of protection against indirect contact by automatic disconnection, protection conditions by automatic disconnection shall be verified according to **18.2**.

c) Insulation resistance test (see **18.3**)

d) Withstand voltage test (see **18.4**)

e) Verification on protection against residual voltage (see **18.5**)

f) Function tests (see **18.6**)

When these tests are performed, they should follow the sequence listed above.

When the electrical equipment is modified, the requirements in **18.7** shall apply.

The tests shall be performed using measuring equipment in accordance with relevant Japanese Industrial Standards and **IEC** Standards. For tests in accordance with **18.2** and **18.3**, measuring equipment conforming to **IEC 61557** series shall be used.

The verification results shall be documented.

18.2 Verification of conditions for protection achievement by automatic disconnection of power supply

18.2.1 General

The condition for automatic disconnection of power supply (see **6.3.3**) shall be verified by tests.

Those test methods for TN earthing systems shall be in accordance with **18.2.2**. Their application for different conditions (machine conditions) of power supply for TN earthing systems shall be in accordance with **18.2.3**.

The verification method for TT earthing systems shall be in accordance with Annex JA.

For the verification method for IT earthing system, see **JIS C 60364-6-61**.

18.2.2 Test method in TN earthing system

The following Test 1 is to verify the continuity of the protective bonding circuit. Test 2 is to verify the conditions for protection by automatic disconnection of the power supply.

Test 1 Verification of the continuity of the protective bonding circuit

The resistance between the PE terminal (see **5.2** and figure 3) and the relevant points of each protective bonding circuit shall be measured with a current between 0.2 A and approximately 10 A derived from an electrically separated a.c. power supply having a maximum no-load voltage of 24 V or d.c. power supply (For example, SELV power supply; see **413.1** of **JIS C 60364-4-41**.) The PELV power supply should not be used since it may cause misleading results. The resistance measured shall be within the expected range according to the length, the cross-sectional area and the material of the related protective bonding conductor.

NOTE 1 Larger currents used for the continuity test increases the accuracy of the test result, especially with low resistance values, i.e. the larger cross-sectional area or the smaller in conductor length.

Test 2 Fault loop impedance verification and suitability of the associated overcurrent protective device

The connections of the power supply conductor and that between the external protective conductor and the PE terminal of the machine shall be verified by the inspection.

The conditions for automatic disconnection of power supply conforming to **6.3.3** and Annex A, shall be verified in accordance with the following **1**) and **2**).

1) The fault loop impedance shall be verified by the following.
   - Calculation, or
   - Measurement in accordance with **A.4**

2) Confirmation that the setting value and the characteristics of the related overcurrent protective device conform to the requirements of Annex A.

NOTE 2 A fault loop impedance test is applicable to the case where the conditions of protection by automatic disconnection requires a disconnection current I_a up to about 1 kA (I_a is the current value causing the automatic disconnection by the disconnector within the time specified in Annex A).

18.2.3 Application of test method for TN earthing system

Test 1 of **18.2.2** shall be performed on each protective bonding circuit of a machine.

When Test 2 of **18.2.2** is performed by measurement, it shall always be preceded by Test 1.

NOTE : Discontinuity of the protective bonding circuit during the loop impedance test may cause a hazardous situation for the tester or other persons, or damage to the electrical equipment.

The tests necessary for machines of different status shall be in accordance with table 9. Table 10 may be used to determine the machine status.

18.3 Insulation resistance tests

When insulation resistance tests are performed, the insulation resistance measured using a megohmeter of 500 V between the power circuits and the protective bonding circuit shall be 1 MΩ or over. The test may be made on individual compartments of the entire electrical equipment.

Exception: For certain parts of the electrical equipment such as the busbars, conductor wire or conductor bar systems or slip-ring assemblies, a lower minimum value is permitted, but that value shall be 50 kΩ or over.

If the electrical equipment of machine contains surge protective devices which are likely to operate during the insulation test, the following are permitted.

— Remove these devices

or

— Reduce the test voltage to a value lower than the voltage protection level of the surge protective devices but not lower than the peak value of the upper limit of the feeding voltage (between neutral conductor and phase conductor).

18.4 Withstand voltage tests

When withstand voltage tests are performed, test equipment conforming to **IEC 61180-2** should be used.

The power supply for testing at a nominal frequency of 50 Hz or 60 Hz shall be used.

The maximum test voltage shall have a value of twice the rated supply voltage of the equipment or 1 000 V, whichever is the larger. The maximum test voltage shall be applied between the phase conductor and the protective bonding circuit for a period of about 1 s.

Components and devices of that are not rated to withstand the test voltage shall be removed during testing.

Components and devices have been withstand-voltage tested in accordance with their product standards may be removed during testing.

18.5 Protection against residual voltage

Where necessary, the test shall be performed to ensure conformance to the requirements of **6.2.4**.

18.6 Function tests

The functions of electrical equipment shall be tested.

The function of circuits for electrical safety (for example, ground fault detection) shall be tested.

18.7 Retesting

Where a portion of the machine and its associated equipment is modified, that portion shall be reverified and retested, if necessary (see **18.1**).

Particular attention should be given to the possible adverse effects that may generate on the equipment by retesting (for example, overstressing of insulation, removal/reconnection of devices).

Table 9 Application of test method in TN earthing system

Procedure	Machine status	Verification on site
A	Assembled/connected electrical equipment of machines on site. The continuity of protective bonding circuits after assembly/connection has not been confirmed.	Test 1 and Test 2 shall be performed. Exception: If previously fault loop impedances or loop resistances have been calculated and the following omitting conditions are satisfied, Test 2 may be omitted. That is, simply, Test 1 is applied to the protective bonding circuit connected on site and the power supply connection and the connection between external protective conductor and PE terminal of machine are visually inspected. Omitting condition of Test 2 • The length and cross-sectional area of conductors used for calculation can be confirmed under the installation conditions. • Power supply impedance on site can be confirmed that it is smaller than the value of power supply impedance assumed at calculation of loop impedance.
B	For the machine having the protective bonding circuit whose cable length is over that given in table 10 which is supplied after the confirmation of continuity verification by measurement for the protective bonding circuit (see **18.1**) in accordance with Test 1 or Test 2, Case B1): it is supplied with fully assembled and not dismantled for shipment. Case B2): it is dismantled for shipment, but the continuity of protective conductors is ensured after dismantling, transportation and reassembly (for example, by the use of plug/socket combinations).	Test 2 shall be performed. Exception: Where the case that the supplied power supply impedance on site is the value used for the calculation or under or the impedance of the power supply for measurement in Test 2 or under is confirmed, the measurement test on site may be omitted and the following verifications is simply performed. In case B1): Verification that the connection of power supply conductors and connection between external protective conductor and PE terminal of machine is correct. In case B2): Verification that the connection of power supply conductor and connection between external protective conductor and PE terminal of machine is correct, and that all connections of the protective conductor that were disconnected for shipment are correct.
C	For the machine having the protective bonding circuit whose cable length is under that of table 10 which is supplied after the confirmation of continuity verification by measurement for the protective bonding circuit (see **18.1**) in accordance with Test 1 or Test 2, Case C1): it is supplied with fully assembled and not dismantled for shipment. Case C2): it is dismantled for shipment, but the continuity of protective conductors is ensured after dismantling, transportation and reassembly (for example, by the use of plug/socket combination).	The test on site may be omitted. For the machine connected to power supply by other than the plug/socket combination, the correct connection between external protective conductor and PE terminal of the machine shall be verified by visual inspection. In case C2): The necessity of verification of the connection (for example, by visual inspection) of all protective conductors disconnected for shipment shall be indicated in the installation documents (see **17.4**).

Table 10 Example of maximum permissible cable length from each protective device to load thereof

1 Power supply impedance for each protective device (mΩ)	**2** Cross-sectional area (mm^2)	**3** Rated value or setting value of protective device I_N (A)	Maximum cable length from each protective device to load (m)				
			4 Fuse Fusing time 5 s	**5** Fuse Fusing time 0.4 s	**6** Miniature circuit breaker Characteristics B (**IEC 60898**) $I_a = 5I_N$ Breaking time 0.1 s	**7** Miniature circuit breaker Characteristics C (**IEC 60898**) $I_a = 10I_N$ Breaking time 0.1 s	**8** Adjustable circuit breaker $I_a = 8I_N$ Breaking time 0.1 s
500	1.5	16	97	53	76	30	28
500	2.5	20	115	57	94	34	36
500	4.0	25	135	66	114	35	38
400	6.0	32	145	59	133	40	42
300	10	50	125	41	132	33	37
200	16	63	175	73	179	55	61
200	25 (phase conductor)/16 (PE)	80	133				38
100	35 (phase conductor)/16 (PE)	100	136				73
100	50 (phase conductor)/25 (PE)	125	141				66
100	70 (phase conductor)/35 (PE)	160	138				46
50	95 (phase conductor)/50 (PE)	200	152				98
50	120 (phase conductor)/70 (PE)	250	157				79

The values of maximum cable length in table 10 are based on the following assumptions.

— PVC cable of copper conductors and conductor temperature under short-circuit condition is 160 °C (see table D.5).

— Multi-core cables with phase conductors (one line) of 16 mm^2 or under in cross-sectional area provide protective conductor of equal cross-sectional area.

— Multi-core cables with phase conductors (one line) of over 16 mm^2 in cross-sectional area provide protective conductor of cross-sectional area shown as slash followed by ×× (PE) (see column 2).

— 3-phase power supply and nominal voltage of power supply is 400 V.

— Maximum supplied power supply impedance to each protective device is in accordance with column 1.

— Value in column 3 is associated with permissible current shown in table 6 (see **12.4**).

NOTE: A deviation from these assumptions shall require a complete calculation or measurement of the fault loop impedance. Further information is shown in **JIS C 3664** and **IEC 61200-53**.

Annex A (normative)
Protection against indirect contact in TN earthing systems

Introduction

This Annex specifies the protection against indirect contact when the power supply of TN earthing systems are used, and is based on **JIS C 60364-4-41**:2006 and **JIS C 60364-6-61**:2006.

A.1 General

Protection against indirect contact shall be provided by an overcurrent protective device that automatically breaks the power supply to the circuit or equipment in the event of a fault between a live part and an exposed conductive part or a protective conductor in the circuit or equipment, within a sufficiently short disconnecting time. A disconnecting time of 5 s or under is considered sufficiently short for the hand-held or portable machines.

Exception: Where this disconnecting time cannot be assured, measures shall be implemented (for example, supplementary protective bonding) to prevent a prospective touch voltage from exceeding 50 V a.c. r.m.s or 120 V (ripple-free) d.c. between simultaneously accessible conductive parts.

NOTE : Generally, as long as the touch voltage is over 50 V, protection against indirect contact cannot be assured during the disconnecting time of 5 s. However, in the case of the distribution line (not the load device) of the TN system, the interrupting time of 5 s is accepted from the following reasons.

a) The probability of failure occurrence in the distribution circuit is small.

b) The device set in the distribution circuit is an install-type device, and the probability of contact with such a device is very small during the period of failure occurrence.

c) This type of device usually has no handle, and people can easily leave at the time of failure.

d) The touch voltage is reduced by equipotential bonding.

e) The most cases can be covered if the interrupting time is 5 s, except that there is a motor as the load of which starting time is long and starting current is large and it is difficult to set up the operating time of an overcurrent protective device short.

f) When the branch circuit for a terminal device is connected to the distribution circuit, local equipotential bonding shall be added to the grounding of the enclosure of the terminal device, and it shall be included in the main equipotential bonding of the system concerned and the requirement for the main equipotential bonding shall be satisfied.

For circuits which feeds the Class I hand-held machine or the portable machine through socket-outlets or directly without socket-outlets, the maximum disconnecting time considered sufficiently short shall be in accordance with table A.1 (for example, see **15.1** for socket-outlets for accessory device on a machine).

Table A.1 Maximum disconnecting times for TN earthing systems

U_0 (V) [a]	Disconnecting time (s)
120	0.8
230	0.4
277	0.4
400	0.2
>400	0.1

NOTE : For voltages within the tolerance range specified in **IEC 60038**, the disconnecting time appropriate to the nominal voltage applies. For intermediate values of voltage, the next higher value in the above table is to be used.

Note [a] U_0 is the nominal voltage to earth (a.c. r.m.s.).

A.2 Conditions for protection by automatic disconnection of power supply by overcurrent protective devices

The characteristics of overcurrent protective devices and the circuit impedances shall be such that the automatic disconnection of power supply shall occur within the specified time (i.e. within 5 s or the value in table A.1) when a ground fault of negligible impedance occurs anywhere in the electrical equipment between a phase conductor and a protective conductor or exposed conductive part. This requirement shall be satisfied when the following equation is established.

$$Z_s \times I_a \leq U_0$$

where, Z_s : the impedance of the ground fault loop comprising the power supply, the live conductor up to the fault point from power supply and the protective conductor up to the power supply from the fault point

I_a : the ground fault current causing the automatic disconnection of the protective device within the specified time

U_0 : the nominal a.c. voltage to earth potential

The increase of the resistance of the conductor with the increase of temperature due to the ground fault current shall be taken into account (see also **A.4.3**).

NOTE : Information for calculation of the short circuit currents can be obtained from, for example, **IEC 60909** series or from suppliers of short-circuit protective devices.

A.3 Condition for protection by reduction of touch voltage to 50 V or under

Where the requirement of clause **A.2** is not satisfied and supplementary protective bonding is selected as the means of ensuring protection against the hazardous touch

voltages, the condition necessary for this protection measure is that the touch voltage has been reduced to 50 V or under and the impedance of the protective circuit does not exceed the value of the following equation.

$$Z_{PE} \leq \frac{50}{U_0} \times Z_s$$

where, Z_{PE} : the impedance of the protective bonding circuit between the device in the machine and electrical equipment, and the PE terminal (see **5.2** and figure 2) or between simultaneously accessible exposed conductive parts and/or external conductive parts

Confirmation of this condition can be achieved by measuring R_{PE} of Test 1 in **18.2.2**. The condition for protection is achieved when the value of R_{PE} does not exceed the value of the following equation.

$$R_{PE} \leq \frac{50}{I_{a(5s)}}$$

where, $I_{a(5s)}$: the current by which protective device operates in 5 s

R_{PE} : the resistance of protective bonding circuit between the device in the machine and electrical equipment, and the PE terminal (see **5.2** and figure 2) or between simultaneously accessible exposed conductive parts and/or external conductive parts

NOTE 1 Supplementary protective bonding is considered as an supplementary measure against indirect contact protection.

NOTE 2 Supplementary protective bonding may involve the entire machine or electrical equipment, or a part of them.

A.4 Verification of conditions for protection by automatic disconnection of power supply

A.4.1 General

The effectiveness of the measures for protection against indirect contact by automatic disconnection of power supply in accordance with clause **A.2** shall be verified as follows.

— Verification of the characteristics of the associated protective device by visual inspection of the nominal running current set values of breakers and the current rating for fuses

and

— Measurement of the fault loop impedance Z_s

Exception: Where the calculated value of the fault loop impedance or of the resistance of the protective conductors are available and when the arrangement of the installation permits the inspection of the length and cross-sectional area of the conductors, verification of the continuity of the protective conductors may replace the measurement.

A.4.2 Measurement of the fault loop impedance

Measurement of the fault loop impedance shall be performed using measuring device that complies with **IEC 61557-3**. The measurement accuracy and the measurement procedure given in the document of the measuring device shall be considered.

Measurement shall be performed when the machine is connected to a power supply having the same frequency as that of the power supply used for the machine operation.

NOTE : An example of a typical arrangement for measuring the ground fault loop impedance on a machine is shown in figure A.1. If it is not practicable for the motor to be connected during the test, the two phase conductors not used in the test may be opened, for example, by removing fuses.

A.4.3 Consideration on the measured value of resistance of the conductors and the actual value under short circuit conditions

NOTE : As the measurement is performed at the normal temperature with low currents, it is necessary to take into account the increase of resistance of the conductors with the increase of temperature by the ground fault current to verify the compliance of the measured value of the fault loop impedance with the requirements of clause **A.2**.

The increase of resistance of the conductors by the increase of temperature due to the ground fault current is taken into account by the following equation.

$$Z_{s(m)} \leq \frac{2}{3} \times \frac{U_o}{I_a}$$

where, $Z_{s(m)}$: the measured value of Z_s

Where the ground fault loop impedance exceeds $2U_o/3I_a$, a more precise assessment can be made in accordance with the procedure described in **E.612.6.3** of **JIS C 60364-6-61**.

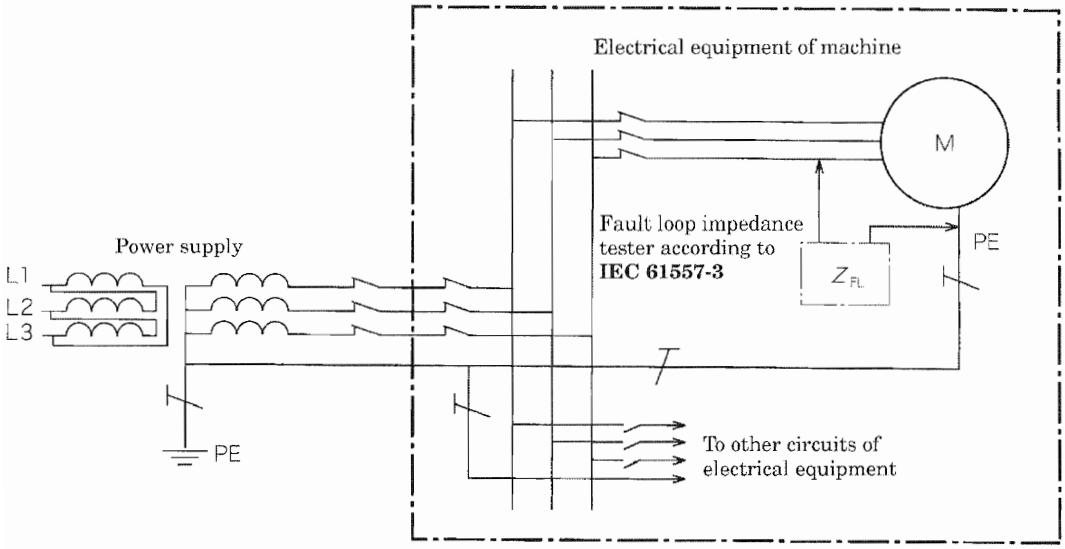


Figure A.1 Example of fault loop impedance measurement

Annex B (informative)
Enquiry form for electrical equipment of machines

Introduction

This Annex is for informative purposes only to the supplier and the user of the electrical equipment of machine, and not to constitute the provisions of this Standard.

B.1 Information shown in the following table (enquiry form) should be provided by the user of the electrical equipment of machine to the supplier. This can facilitate an agreement between the user and the supplier upon basic conditions and additional requirements from the user to enable the proper design, application and utilization of the electrical equipment of machines (see **4.1**).

Enquiry item	Entry			
Name of manufacturer/supplier				
Name of end user				
Tender number/order number			Date	
Type of machine			Serial number	
1 Special conditions (see clause **1** of the text)	—			
a) Is the machine to be used in the open air?	Yes/No		—	
b) Will the machine use, process or produce explosive or flammable material?	Yes/No		If yes, specification	
c) Is the machine for use in potentially explosive or flammable atmospheres?	Yes/No		If yes, specification	
d) Can the machine present special hazards when producing or consuming certain materials?	Yes/No		If yes, specification	
e) Is the machine for use in mines?	Yes/No		—	
2 Power supply conditions (see **4.3**)	—			
a) Anticipated voltage fluctuations (if more than ±10 %)				
b) Anticipated frequency fluctuations (if more than ±2 %)	Continuous		Short time	
c) Indicate possible future changes in electrical equipment that will require an addition of power supply conditions				
d) Specify voltage interruptions in power supply if longer than specified in clause **4** when electrical equipment has to maintain normal operation under such conditions				
3 Physical environment and operating conditions (see **4.4**)	—			
a) Electromagnetic environment (see **4.4.2**)	Residential, commercial or light industrial environment		Industrial environment	

Enquiry item	Entry			
Special conditions or requirements				
b) Ambient temperature range				
c) Humidity range				
d) Altitude (above sea level)				
e) Special environmental conditions (for example, corrosive atmospheres, dust, wet environments)				
f) Radiation				
g) Vibration, shock				
h) Special requirements for installation and operation (for example, flame-retardant cables and conductors)				
i) Transportation and storage (for example, temperatures outside the range specified in **4.5**)				
4 Incoming power supply	—			
Specify for each power supply				
a) Nominal voltage (V)	a.c.		d.c.	
If a.c.,	Number of phases		Frequency	
Prospective short-circuit current at the point of power supply to the machine (kA r.m.s.) (see also item 2)	kA r.m.s.			
b) Type of power supply earthing system (see **JIS C 60364-1**)	TN: earthing system with one point directly earthed, with a protective conductor (PE) directly connected to that point; specify if the earthed point is the neutral point (centre of the star) or another point		TT: earthing system with one point directly earthed but the protective conductor (PE) of the machine not connected to that earthed point of the system	
	IT: system that power supply is not directly earthed			
c) Is the electrical equipment to be connected to a neutral conductor (N) of power supply? (see **5.1**)	Yes		No	
d) Power supply breaker	—			
Is disconnection of the neutral conductor (N) required?	Yes		No	
Is a removable link for disconnecting the neutral conductor (N) required?	Yes		No	
Type of power supply breaker to be provided				

Enquiry item	Entry			
5 Protection against electric shock (see clause **6** of the text)	—			
a) For which of the classes of persons is access to the interior of enclosures required during normal operation of the equipment?	Electrically skilled persons		Electrically instructed persons	
b) Are locks with removable keys to be provided for securing the doors or covers? (see **6.2.2**)	Yes		No	
c) Is the residual current breaker for indirect contact protection to be provided in the electrical equipment? If provided, what are the characteristics? (see **6.3.3**)	Yes		No	
6 Protection of equipment (see clause **7** of the text)	—			
a) Will the user or the supplier provide the overcurrent protective device of the feeding conductors (outside of constitution)? (see **7.2.2**)	Yes		No	
Type and rating of overcurrent protective devices	Type		Rating	
b) Maximum output (kW) of three-phase a.c. motor that may be started direct-on-line by directly connecting to power supply				
c) May the number of motor overload detection devices be reduced? (see **7.3**)	Yes		No	
7 Operation	—			
For cableless control systems, specify the time delay before automatic machine shutdown is initiated in the absence of a valid signal.	s			
8 Operator interface and machine-mounted control devices (see clause **10** of the text)	—			
Special colour preferences (for example, to align with existing machinery):	Start		Stop	
	Other			
9 Controlgear	—			
Degree of protection of enclosures (see **11.3**) or special conditions				
10 Wiring practices (see clause **13** of the text)	—			
Is there a specific method of identification to be used for the conductors? (see **13.2.1**)	Yes		No	
	Type			
11 Accessories and lighting (see clause **15** of the text)	—			
a) Is a particular type of socket-outlet required?	Yes		No	
	Type			
b) Are the socket-outlets for maintenance to be provide with additional protection by the use of Residual Current protective Devices (RCD)?	Yes		No	

Enquiry item	Entry			
c) Where the machine is equipped with local lighting	Highest permissible voltage (V)		If lighting circuit voltage is not obtained directly from the power supply, state preferred voltage	
12 Marking, warning signs and reference designations (see clause **16** of the text)	—			
a) Functional identification (see **16.3**)				
Specifications				
b) Inscriptions/special markings	On electrical equipment?		In which language?	
c) Mark of certification	Yes		No	
	Which certification institution?			
13 Technical documentation (see clause **17** of the text)				
a) Technical documentation (see **17.1**)	On what media?		In which language?	
b) Size, location and purpose of ducts, open cable trays or cable supports to be provided by the user (see **17.5**)				
c) Indicate if special limitations on the dimensions or weight affect the transport of a particular machine or controlgear assemblies to the installation site	Maximum dimensions		Maximum weight	
d) In the case of specially built machines, is a certificate of operating tests with the loaded machine to be supplied?	Yes		No	
e) In the case of other machines, is a certificate of operating type tests on a loaded prototype machine to be supplied?	Yes		No	

Annex C (informative)
Examples of machines covered by this Standard

Introduction

This Annex is to show examples of machines covered by this Standard and not to constitute the provisions of this Standard.

C.1 Example of machine covered by this Standard

The following list shows examples of machines whose electrical equipment should conform to this Standard. The list is not intended to be exhaustive but is consistent with the definition of machinery (see **3.35**).

This Standard need not be applied to machines that are household and similar domestic appliances within the scope of the **IEC 60335** series.

Metalworking machinery

- metal cutting machines
- metal forming machines

Plastics and rubber machinery

- injection moulding machines
- extrusion machines
- blow moulding machines
- thermoset moulding machines
- size reduction machines

Wood machinery

- woodworking machines
- laminating machines
- sawmill machines

Assembly machines

Material handling machines

- robots
- conveyors
- transfer machines
- storage and retrieval machines

Textile machines

Refrigeration and air-conditioning machines

Food machinery

- dough breaks
- mixing machines
- pie and tart machines
- meat processing machines

Printing, paper and board machinery

- printing machines
- finishing machines, guillotines, folders
- reeling and slitting machines
- folder box gluing machines
- paper and board making machines

Inspecting/testing machinery

- co-ordinate measuring machines
- in-process gauging machines

Compressors

Packaging machinery

- palletizers/depalletizers
- wrapping and shrink-wrapping machines

Laundry machines

Heating and ventilating machines

Leather/imitation leather goods and footwear machinery

- cutting and punching machines
- roughing, scouring, buffing, trimming and brushing machines
- footwear moulding machines
- lasting machines

Hoisting machinery

- cranes
- hoists

Machinery for transportation of persons

- escalators
- ropeways for transportation of persons, for example chairlifts, ski lifts
- passenger lifts

Power-operated doors

Leisure machinery

— fairground riders

Pumps

Agriculture and forestry machines

Construction and building materials machinery

— tunnelling machines

— concrete batching machines

— brick-making machines

— stone, ceramic and glass-making machines

Transportable machinery

— wood working machines

— metal working machines

Mobile machinery

— lifting platforms

— fork lift trucks

— construction machines

Machines for hot metal processing

Tanning machinery

— multi-roller machines

— bandknife machines

— hydraulic tanning machines

Mining and quarrying machines

Annex D (informative)
Current-carrying capacity and overcurrent protection of conductors and cables in electrical equipment of machines

Introduction

This Annex is for informative purposes only and not to constitute the provisions of this Standard.

The purpose of this Annex is to provide additional information on the selection of conductor sizes where the conditions given in table 6 (see clause **12**) have to be modified (see NOTE of table 6).

D1 General use conditions

D.1.1 Ambient temperature

The current carrying capacity for PVC insulated copper conductors given in table 6 is related to an ambient temperature of +40 °C. For other ambient air temperatures, the value can be corrected by using the correction factors given in table D.1.

The correction factors for rubber insulated cables are given by the manufacturer.

Table D.1 Correction factors for current-carrying capacity

Ambient temperature °C	Correction factor
30	1.15
35	1.08
40	1.00
45	0.91
50	0.82
55	0.71
60	0.58

NOTE : The correction factors are derived from **JIS C 60364-5-52.**

The maximum temperature under normal conditions for PVC 70 °C.

D.1.2 Installation method

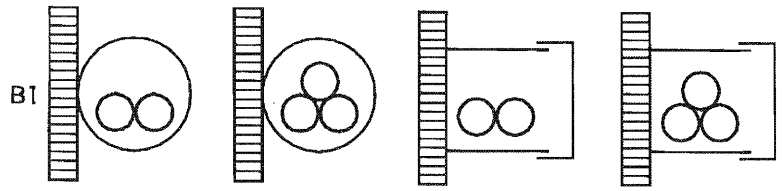
In machines, the methods of conductor and cable installation between enclosures and individual items of the equipment shown in figure D.1 are assumed to be typical (the letters for installation method used are in accordance with **JIS C 60364-5-52**).

Method B1: using conduits (see **3.7**) and cable trunking systems (see **3.5**) for holding and protecting conductors or single core cables

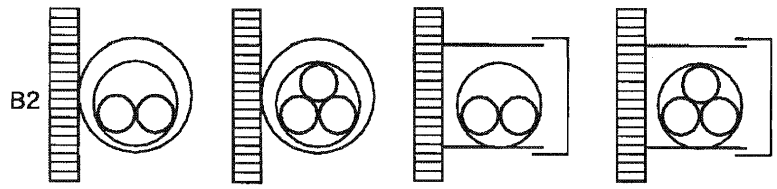
Method B2: same as B1 but used for multi core cables

Method C: multi core cables installed in free air, horizontal or vertical without gap between cables on walls

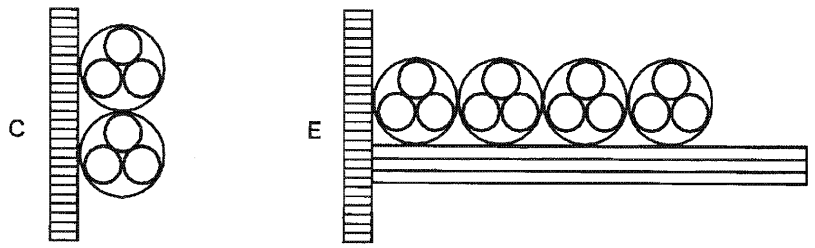
Method E: multi core cables in free air, horizontal or vertical laid on open cable trays (see **3.4**)



Conductors/single core cables in conduit and cable trunking systems



Cables in conduit and cable trunking systems



Cables on walls **Cables on open cable trays**

Figure D.1 Installation methods conductors and cable (independent of number of conductors/cables)

D.1.3 Dense installation (grouping installation)

When the number of circuits or the number of pairs of the conductor which passes load current in the cable or in the bundle to be installed is more than that given in the condition of table 6, it can be derated in accordance with table D.2 and table D.3 from the value of I_z given in table 6 or the allowable current value given by the cable manufacturer.

NOTE : Derating is not necessary for the circuit in which I_b (design current) does not exceed 30 % of I_z (current-carrying capacity).

Table D.2 Derating factors from I_z of single installation applied for dense installation

Installation method (see figure D.1) (see NOTE 3)	Number of conductor/cable where load current passes			
	2	4	6	9
B1: (for single core cables) and B2: (for multi core cables)	0.80	0.65	0.57	0.50
C: Single-layer cables installed without gap	0.85	0.75	0.72	0.70
E: Cables installed in single layer without gap on one tray having holes	0.88	0.77	0.73	0.72
E: Cables installed in single layer without gap on tray having holes located in 2 to 3 steps at vertical intervals of 300 mm (see NOTE 4)	0.86	0.76	0.71	0.66
Pair wires of control circuit of 0.5 m^2 or under (independent of installation method)	0.76	0.57	0.48	0.40

NOTE 1 Factors in this table may be applicable to the following.
- — cables in which load current passes equally to each core and conductor pair in which load current passes symmetrically
- — groups of insulated conductors and cables having the same allowable maximum operating temperature

NOTE 2 Factors in this table may also applicable to the following.
- — groups of two or three single core cables
- — multi core cables

NOTE 3 Factors in this table are derived from **JIS C 60364-5-52.**

NOTE 4 A cable tray having holes (perforated cable tray) is a tray where holes occupy 30 % or over of the bottom area (see Annex A of **JIS C 60364-5-52**).

Table D.3 Derating factors from I_z of multi core cables (conductors of cross-sectional area of 10 mm^2 or under)

Number of single wires or pair wires in which load current passes	Conductors of cross-sectional area of over 1 mm^2 (see NOTE 3)	Pair wires of cross-sectional area of 0.25 mm^2 to 0.75 mm^2
1	—	1.0
3	1.0	—
5	0.75	0.39
7	0.65	0.34
10	0.55	0.29
24	0.40	0.21

NOTE 1 Factors are applicable to multi core cables of single wire or air wire in which load current passes equally.

NOTE 2 See derating factors of table D.2 for grouping of multi core cables (dense installation).

NOTE 3 Factors in this table are derived from **JIS C 60364-5-52.**

D.1.4 Classification of conductors

Conductors should be classified in accordance with table D.4.

Table D.4 Classification of conductors

Class	Description	Use
1	Solid copper or aluminium conductors	Fixed installations
2	Stranded copper or aluminium conductors	
5	Flexible stranded copper conductors	Machine installations with presence of vibration Connection to moving parts
6	Flexible stranded copper conductors that are more flexible than Class 5	For frequent movements
NOTE : This table is derived from **JIS C 3664**.		

D.2 Co-ordination between conductors and overload protective devices

Figure D.2 shows the relationship between the parameters of conductors and the parameters of overload protective devices.

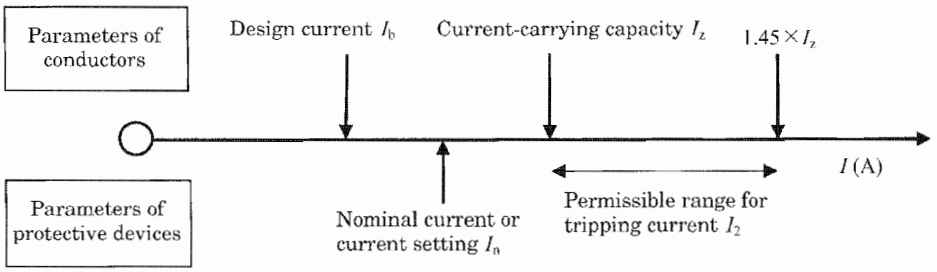


Figure D.2 Parameters of conductors and protective devices

Correct protection of a cable requires that the operating characteristics of a protective device (for example, overcurrent protective device, motor overload protective device) protecting the cable against overload satisfy the following conditions.

$$I_b \leq I_n \leq I_z \quad \cdots\cdots (1)$$

$$I_2 \leq 1.45 \times I_z \quad \cdots\cdots (2)$$

where, I_b : design current of circuit

I_z : effective current-carrying capacity of the cable for continuous service according to table 6 in actual use condition (A)

- See table D.1 for derating factor of I_z for temperature
- See table D.2 for derating factor of I_z for dense installation
- See table D.3 for derating factor of I_z for multi core cables

I_n : the nominal current of the protective device

NOTE 1 The nominal current I_n of the protective device whose operation value is adjustable is the selected set value.

I_2 : the minimum current ensuring effective operation of the protective device within a specified time (for example, within 1 h for protective devices of 63 A or under)

The minimum current I_2 ensuring effective operation of the protective device is given in the product standard or provided by the manufacturer.

NOTE 2 For motor circuit conductors, overcurrent protection for conductor(s) can be provided by the overload protection for the motor(s) whereas the short-circuit protection is provided by short-circuit protective devices.

Where a device that provides both overload and overcurrent protection is used in accordance with clause **D.2** for conductor overload protection, it does not ensure complete protection in all cases (for example, overload with currents less than I_2), nor will it necessarily result in an economical solution. Therefore, such a device can be unsuitable where overloads with currents less than I_2 are likely to occur.

D.3 Overcurrent protection of conductors

All conductors are required to be protected against overcurrent (see **7.2**) by protective devices integrated in the circuit of all live conductors so that any short-circuit current is disconnected before the conductor has reached the maximum allowable temperature.

NOTE : For neutral conductors, see **7.2.3** (second paragraph).

Table D.5 Maximum allowable conductor temperatures under normal and short-circuit conditions

Type of insulation	Maximum allowable conductor temperature under normal conditions °C	Maximum short-time allowable conductor temperature under short circuit conditions [a] °C
Polyvinyl chloride (PVC)	70	160
Rubber	60	200
Cross-linked polyethylene (XLPE)	90	250
Ethylene propylene compound (EPR)	90	250
Silicone rubber (SiR)	180	350
NOTE : For short-time conductor temperatures of 200 °C or over, neither tinned nor bare copper conductors are suitable. Silver-plated or nickel-plated copper conductors are suitable for use above 200 °C.		
Note [a] These values are based on the assumption of adiabatic behaviour for a elapsed period within 5 s.		

In practice, the requirements of **7.2** are satisfied when the protective device at a current I causes the interruption of the circuit within a time t of under 5 s.

The value of the time t (s) is calculated by the following equation.

$$t = (k \times S/I)^2 < 5 \text{ s}$$

where, S : cross-sectional area (mm^2)

I : effective short-circuit current (A), for a.c. as the r.m.s. value

k : factor shown for copper conductors when insulated with the following material

PVC	115
Rubber	141
SiR	132
XLPE	143
EPR	143

The use of fuses with characteristics gG or gM (see **IEC 60269-1**) and circuit-breakers with characteristics B and C in accordance with the **IEC 60898**, ensures that the temperature limits in table D.5 will not be exceeded, provided that the nominal current I_n is chosen in accordance with table 6 where $I_n \leq I_z$.

Annex E (informative)
Explanation of emergency operation functions

Introduction

This Annex is for informative purposes only, and not to constitute the provisions of this Standard.

E.1 Explanation of emergency operation functions

Related terms are given herein to aid the understanding of emergency operation functions; however, two of them are used in this Standard.

Emergency operation

Emergency operation includes the operation alone or the operation in combination of the following.

- emergency stop
- emergency start
- emergency switching off
- emergency switching on

Emergency stop

An emergency operation intended to stop a process or a movement that has become hazardous.

Emergency start

An emergency operation intended to start a process or a movement to remove or to avoid a hazardous situation.

Emergency switching off

An emergency operation intended to switch off the supply of electrical energy to all or a part of an installation where a risk of electric shock or another risk of electrical origin is involved.

Emergency switching on

An emergency operation intended to switch on the supply of electrical energy to a part of an installation that is intended to be used for emergency situations.

Annex F (informative)
Guide for the use of this Standard

Introduction

This Annex is for informative purposes only, and not to constitute the provisions of this Standard.

This Standard gives a large number of general requirements to the electrical equipment of machines; however, the requirements may or may not be applicable to the electrical equipment of a particular machine. Therefore, a simple reference without any qualification to this complete Standard is not sufficient. Choices need to be made to cover the requirements of this Standard.

F.1 Guide for use

A technical committee preparing a product family standard or a dedicated product standard, and the supplier of a machine for which no product family standard or dedicated product standard exists should use this Standard as follows.

a) apply completely as a reference

b) apply by selecting of the most appropriate requirements from those given in the relevant requirements

c) apply by modifying corresponding clauses, as necessary, where the particular requirements for the equipment of machine are adequately covered by other relevant standards.

When applying the selections and the modifications of this Standard, the protection level required for that machine according to the risk assessment should not be adversely affected.

When applying three principles of **a**), **b**) and **c**) above, the following methods should be used.

— show the reference of relevant clauses and subclauses of this Standard

  1) indicate items to be applied without modification selected from this Standard

  2) indicate items to be applied that have been modified or extended for the specific machine or equipment

— show the direct reference to the relevant standard which specifies requirements for the corresponding electrical equipment

In all cases, expertise is essential to be able to achieve the following.

— perform the necessary risk assessment of the corresponding machine

— read and understand all of the requirements of this Standard

— select the applicable requirements from options given in this Standard

— identify alternative or additional particular requirements that differ from or are not included in the requirements of this Standard, which are determined by the machine and its use

— specify precisely those particular requirements

Figure 1 of this Standard is a block diagram of a typical machine and should be used as the starting point of the application of this Standard. Figure 1 shows the clause number which specifies particular requirements/equipment.

Table F.1 shows the options of application method and other related standards when this Standard is applied to a particular machine.

Table F.1 Options of application method of this Standard

Specification item	Clause number	i)	ii)	iii)	iv)
Scope	**1**		○		
General requirements	**4**	○	○	○	**JIS B 9700** series **JIS B 9702**
Selection of equipment	**4.2.2**		○	○	**IEC 60439** series
Incoming power supply disconnector	**5.3**	○			
Excepted circuits	**5.3.5**	○		○	**JIS B 9700** series
Prevention of unexpected start-up, disconnection	**5.4**, **5.5** and **5.6**	○	○	○	**JIS B 9714**
Protection against electric shock	**6**	○			**JIS C 60364-4-41**
Emergency operations	**9.2.5.4**	○		○	**JIS B 9703**
Two-hand operation control	**9.2.6.2**	○	○		**JIS B 9712**
Cableless control	**9.2.7**	○	○	○	
Control functions in case of failure	**9.4**	○	○	○	**JIS B 9702** **JIS B 9705-1** **JIS B 9961** **ISO 13849-2**
Position sensors	**10.1.4**	○	○	○	**JIS B 9710**
Colours and markings of control devices and indicators	**10.2**, **10.3** and **10.4**	○	○		**JIS C 0448** **JIS B 9706** series
Emergency stop devices	**10.7**	○	○		**JIS B 9703**
Emergency switching off devices	**10.8**	○			
Controlgear—protection against ingress of contaminants, etc.	**10.1.3** and **11.3**	○	○	○	**JIS C 0920**
Identification of conductors	**13.2**	○	○		
Verification	**18**	○	○	○	
Additional user requirements	Annex B		○	○	

In this table, when the following i) to iv) are chosen in determining the requirements of a particular machine, the clauses in this Standard to be considered are shown with a ○ mark in the columns of i) to iii), and the standard numbers of other standards to be considered are shown in the column of iv).

i) selection from the means given in this Standard

ii) application of this Standard and additional requirements

iii) application of other requirements

iv) application of other related standards

Annex G (informative)
Comparison of cross-sectional areas of typical conductor

Introduction

This Annex is for informative purposes only, and not to constitute the provisions of this Standard.

Comparison table of cross-sectional areas of conductor

Table G.1 shows a comparison among the conductor size and the American Wire Gauge (AWG), the cross-sectional areas of conductor (mm^2, square inches) and the circular mils [1)].

Note [1)] Circular mils refer to cross-sectional areas of a conductor which expresses the cross-sectional area of a circle of 0.001 inch in diameter as one unit.

Table G.1 Comparison of conductor sizes

Conductor size	Gauge No.	Cross-sectional area		d.c. resistance of copper (20 °C)	Circular mils
mm^2	(AWG)	mm^2	inches ^{2}	Ω/km	
0.2		0.196	0.000 304	91.62	387
	24	0.205	0.000 317	87.60	404
0.3		0.283	0.000 438	63.46	558
	22	0.324	0.000 504	55.44	640
0.5		0.500	0.000 775	36.70	987
	20	0.519	0.000 802	34.45	1 020
0.75		0.750	0.001 162	24.80	1 480
	18	0.823	0.001 272	20.95	1 620
1.0		1.000	0.001 550	18.20	1 973
	16	1.31	0.002 026	13.19	2 580
1.5		1.500	0.002 325	12.20	2 960
	14	2.08	0.003 228	8.442	4 110
2.5		2.500	0.003 875	7.56	4 934
	12	3.31	0.005 129	5.315	6 530
4		4.000	0.006 200	4.700	7 894
	10	5.26	0.008 152	3.335	10 380
6		6.000	0.009 300	3.110	11 841
	8	8.37	0.012 967	2.093	16 510
10		10.000	0.001 550	1.840	19 735
	6	13.3	0.020 610	1.320	26 240
16		16.000	0.024 800	1.160	31 576
	4	21.1	0.032 780	0.829 5	41 740
25		25.000	0.038 800	0.734 0	49 338
	2	33.6	0.052 100	0.521 1	66 360
35		35.000	0.054 200	0.529 0	69 073
	1	42.4	0.065 700	0.413 9	83 690
50		47.000	0.072 800	0.391 0	92 756

The resistance for temperatures other than 20 °C can be calculated by the following equation.

$$R = R1\ [1 + 0.003\ 93\ (t - 20)]$$

where, $R1$: resistance at 20 °C

R : resistance at a temperature t °C

Annex JA (normative)
Protection against indirect contact in TT earthing systems

Introduction

This Annex specifies the protection against indirect contact when the power supply of TT earthing system is used, and is based on **JIS C 60364-4-41** : 2006 and **JIS C 60364-6-61** : 2006. The TT earthing system is a standard system used in Japan.

JA.1 Power supply automatic disconnection by residual current breaker

Where the protection against indirect contact is performed by the residual current detection and the power supply automatic disconnection, the power supply shall automatically be disconnected within the sufficiently short breaking time when the insulation failure occurs between the live part and the exposed conductive part or the protective conductor in the equipment intended for protection.

The power supply automatic disconnection shall conform to the following conditions.

$$R_A \times I_a \leq 50 \text{ V} \quad \cdots\cdots (1)$$

where, R_A : sum of the resistance of the protective conductor connected to exposed conductive parts and the earthing resistance of the earthing electrode (Ω)

I_a : the rated operating current of the protective device (A)

When the protective device is a residual current breaker, I_a shall be the rated sensitivity current $I_{\Delta n}$.

When the protective device is an overcurrent protective device, I_a shall be either of the following.

— For the protective device with reverse time characteristics, I_a shall be the electric current which enables automatic disconnection within 5 s

or

— For the protective device with instantaneous tripping characteristics, I_a shall be the electric current which enables instantaneous tripping.

When this condition cannot be satisfied, an auxiliary equipotential bonding shall be applied.

NOTE : The overcurrent protective device can be used for the protection against indirect contact of TT earthing system only when R_A is very low. Since I_a of the overcurrent protective device is of the order of ampere (it is necessary to set to the larger current value than the load current value at the time of start-up) while I_a of the residual current breaker is generally of the order of milliampere, it is generally difficult to satisfy the condition of the equation (1) by the overcurrent protective device. For example, although when $I_a = 50$ A, R_A shall be set to 1 Ω or under, generally it is not easy to obtain the earthing resistance of 1 Ω or under. According to this, the protection against indirect contact in TT earthing system is generally performed by the residual current breaker.

The maximum breaking time of the residual current breaker to the estimated touch voltage (U_t) for the protection against indirect contact in TT earthing system is specified in table JA.1. The exposed conductive part shall be grounded by Class C earthing works (earthing resistance value of 10 Ω or under) or Class D earthing works (earthing resistance value of 100 Ω or under) specified in the technical standards for electrical installations (compulsory legislation).

Table JA.1 Permissible maximum breaking time of residual current breaker in TT earthing system

U_t (V)	Breaking time (s)
120	0.33
230	0.16
277	0.13
400	0.07
500	0.04

NOTE 1 U_t is the estimated touch voltage at the time of indirect contact (a.c. r.m.s.). When the estimated touch voltage U_t at the time of indirect contact cannot be estimated, the nominal voltage to the ground U_0 (a.c. r.m.s.) is applicable. To the voltage of an intermediate value, the breaking time for the nearest voltage higher than it in the table shall be applied.

NOTE 2 This table is derived from figure 2 of **IEC 61200-413**.

JA.2 Verification of conditions under which protection is achieved by power supply automatic disconnection using residual current breaker

In order to verify the efficacy of the indirect contact protective measures by the power supply automatic disconnection using the residual current breaker given in JA.1, at least the following shall be performed.

— Visual inspection of the rated sensitivity current value and the residual current tripping time of the residual current breaker, operation test of the residual current breaker, and confirmation of the secure connection (welding, thread-fastening torque) of the connection point of the residual current breaker and the protection bonding circuit

— Measurement of earthing resistance of the earthing electrode which grounds the exposed conductive part of the electrical equipment (to be 100 Ω or under)

Exception: When the earthing electrode is controlled by the required grounding resistance value of Class D earthing (earthing resistance of 100 Ω or under), the calculated value of resistance of a protective conductor exists, and the length and the cross-sectional area of an external protective conductor can be inspected in a state of installation, only the confirmation of conduction (connection) of a protective conductor is good enough.

NOTE : The verification of operation of a residual current breaker and the measuring method of the earthing resistance are described in Annex of **JIS C 60364-6-61**.

Annex JB (informative)
Correspondence between aspects and clauses this Standard specifies

Introduction

This Annex is to describe in order to aid the understanding of this Standard, and not to constitute the provisions of this Standard.

JB.1 Correspondence between aspects and clauses this Standard specifies

Although this Standard specifies mainly the safety aspects of the electrical equipment of machinery, it is not limited only to safety. This Standard specifies the following aspects.

— Protection of person

— Protection of property (things)

— Consistency of control response

— Ease of maintenance

The protection of property means to protect the work in progress, the machine and the electrical equipment itself from being damaged.

The correspondence of clauses especially related to each aspect of the classified items above mentioned are shown in table JB.1. However, each clause does not necessarily specify only the particular aspect and may specify other aspects partly.

Table JB.1 Correspondence of clauses and aspects this Standard specifies

	Aspects this Standard specifies			
	Protection of person	Protection of property (things)	Consistency of control response	Ease of maintenance
Clause number and title in which specified aspect is treated	**5** Connection of incoming power supply conductors, disconnectors and devices for switching off **6** Protection against electric shock **8** Equipotential bonding **9** Control circuits and control functions **12** Conductors and cables **13** Wiring **14** Electric motors and associated equipment **18** Verification	**7** Protection of equipment **12** Conductors and cable **13** Wiring **14** Electric motors and associated equipment	**8** Equipotential bonding **9** Control circuits and control functions **10** Operator interface and machine-mounted control devices **11** Controlgear: location, mounting and enclosures	**13** Wiring **15** Accessories and lighting **16** Marking, warning signs and reference designations **17** Technical documentation

Annex JC (informative)
Degrees of protection provided by enclosures

Introduction

This Annex is to describe in order to aid the understanding of this Standard, and not to constitute the provisions of this Standard.

This Standard specifies the protection performance of the enclosure required for the protection against electric shock and the equipment protection. In order to indicate the protection performance, the degree of protection specified in **JIS C 0920** is referred to. The enclosure means a structure which covers an electrical circuit etc. (see **3.20**).

This Annex is for the explanation of the degrees of protection (IP code) and the meaning of the symbol (protection performance) provided by the enclosures which this Standard requires.

JC.1 Meaning of IP code (JIS C 0920)

Enclosures have the following purposes.

— Protection of human bodies against access to hazardous parts inside the enclosure (protection against electric shock)

— Protection of electrical devices inside the enclosure against ingress of solid foreign objects

— Protection of electrical devices inside the enclosure against ingress of water with harmful effects

The degree of protection provided by enclosures refers to a degree indicating the protection rate of human bodies against access to hazardous parts inside the enclosure, and protection against the ingress of solid foreign object and/or the ingress of water. The degree of protection provided by the enclosure (IP code) is specified in **JIS C 0920**.

The IP code in **JIS C 0920** is indicated as follows. The meaning of a letter and a numeral is as given in table JC.1.

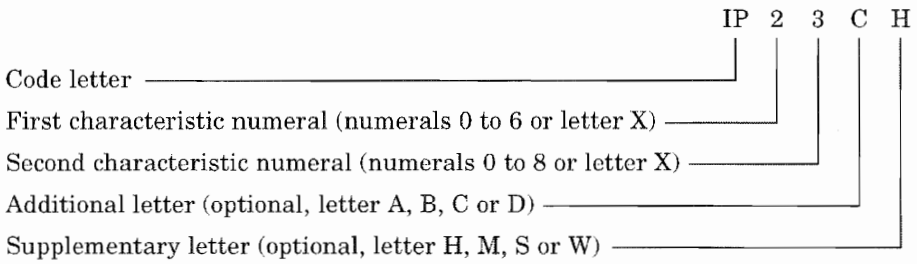


Table JC.1 Meaning of IP code

	Degree	Protection for electrical device	Protection for person
First characteristic numeral		Ingress of solid foreign objects	Access to hazardous parts
	0	Non-protected	Non-protected
	1	Diameter ≥ 50 mm	Back of hand
	2	Diameter ≥ 12.5 mm	Finger
	3	Diameter ≥ 2.5 mm	Tool
	4	Diameter ≥ 1.0 mm	Wire
	5	Dust-protected	Wire
	6	Dust-tight	Wire
	X	Degrees of 0 to 6 are not specified.	Same as on the left
Second characteristic numeral		Ingress of water with harmful effects	
	0	Non-protected	
	1	Vertically dripping	
	2	Dripping (±15° tilted)	
	3	Spraying	
	4	Splashing	
	5	Jetting	
	6	Powerful jetting	
	7	Temporary immersion	
	8	Continuous immersion	
	X	Degrees of 0 to 8 are not specified.	
Additional letter (optional)			Access to hazardous parts
	A		Back of hand
	B		Finger
	C		Tool
	D		Wire
Supplementary letter (optional)		Supplementary indication	
	H	High voltage device	
	M	Motion during water test	
	S	Stationary during water test	
	W	Weather conditions	

JC.2 Summary of degrees of protection by enclosures required in this Standard

This Standard specifies the degrees of protection by the enclosures in **6.2.1**, **6.2.2**, **6.2.4** and **11.3**. The IP code required in this Standard consists of two digits or three digits. In the case of two digits, there is no characteristic requirement by two auxiliary letters. In the case of three digits, there is no characteristic requirement by the last auxiliary letter.

The degrees of protection provided by the enclosures which each subclause of this Standard specifies and the meanings thereof are given in table JC.2.

Table JC.2 Degree of protection provided by enclosure and meanings thereof required in this Standard

Sub-clause	Type of enclosure	Required degree of protection (IP code)	Meaning of IP code
6.2.1	Enclosures which cover the electrical equipment at places accessible to persons	IP4X or	Protect against the ingress of solid objects and wires of 1 mm or over in diameter. No requirement for waterproof property.
		IPXXD	Protect against the ingress of wires. No requirement for waterproof property.
6.2.2	• Enclosures which cover the live part • Enclosures which cover the remaining live parts even after a breaker is made to be off	IP2X or	Protect against the ingress of solid objects of 12.5 mm or over in diameter and fingers. No requirement for waterproof property.
		IPXXB	Protect against the ingress of fingers. No requirement for waterproof property.
	Enclosures which cover the top surfaces of live parts readily accessible to persons	IP4X or	Protect against the ingress of solid objects and wires of 1 mm or over in diameter. No requirement for waterproof property.
		IPXXD	Protect against the ingress of wires. No requirement for waterproof property.
	Enclosures which cover other live parts inside door	IP1X or	Protect against the ingress of solid objects of 50 mm or over in diameter and back of hand. No requirement for waterproof property.
		IPXXA	Protect against the ingress of back of hand. No requirement for waterproof property.
6.2.4	Enclosures which cover plugs of which conductors are exposed when they are withdrawn and do not discharge within 1 s	IP2X or	Protect against the ingress of solid objects of 12.5 mm or over in diameter and fingers. No requirement for waterproof property.
		IPXXB	Protect against the ingress of fingers. No requirement for waterproof property.
10.1.3	Enclosures which cover the live parts of an operator-interface devices.	IPXXD	Protect against the ingress of wires. No requirement for waterproof property.
11.3	Enclosures of controlgear	IP22	Protect against the ingress of solid objects of 12.5 mm or over in diameter and fingers. Protect against vertical dripping water when enclosure is tilted at ±15°
	Ventilated enclosure containing only large-size equipment	IP10	Protect against the ingress of solid objects of 50 mm or over in diameter. No requirement for waterproof property and ingress of human bodies.
	Ventilated enclosure containing other types of equipment	IP33	Protect against the ingress of solid objects of 2.5 mm or over in diameter and tools. Protect against the ingress of spraying water.
	Enclosure used in general industry	IP33	Ditto
		IP43	Protect against the ingress of solid objects of 1 mm or over in diameter and wires. Protect against the ingress of spraying water.
		IP54	Dust-protected, and protect against the ingress of wires. Protect against the ingress of splashing water.
	Enclosure used in places where cleaned with low-pressure water	IP55	Dust-protected, and protect against the ingress of wires. Protect against the ingress of jetting water.
	Enclosure providing protection against dust	IP65	Dust-tight, and protect against the ingress of wires. Protect against the ingress of jetting water.
	Enclosure containing a slip-ring mechanism	IP2X	Protect against the ingress of solid objects of 12.5 mm or over in diameter and fingers. No requirement for waterproof property.

Annex JD (informative)
Class of electrical equipment (classification by protection against electric shock)

Introduction

This Annex is to describe in order to aid the understanding of this Standard, and not to constitute the provisions of this Standard.

In this Standard, the term of "Class" of the electrical equipment classified from the viewpoint of protection against the electric shock is used. The "Class" which is used in this Standard is based on **JIS C 0365**. This Annex summarizes and explains the meaning of the "Class" which **JIS C 0365** specifies.

JD.1 Location of use of "Class" of electrical equipment

Subclauses in which this Standard uses the "Class" of electrical equipment are given in table JD.1.

Table JD.1 Location of use of "Class" of electrical equipment

Term	Location of use
Class	NOTE 2 of **6.3.1**
Class I equipment	Annex A
Class II equipment	**6.3.2.1** and **6.3.2.2**
Class III equipment	**12.3**

JD.2 Meaning of "Class" of electrical equipment (JIS C 0365)

The meaning of each class which **JIS C 0365** specifies is given in table JD.2.

Table JD.2 Meaning of "Class" of electrical equipment

Classification	Meaning
Class I equipment	Equipment which has basic insulation as an element of the means for basic protection, and has protective bonding as an element of the means for failure protection
Class II equipment	Class II equipment refers to the following. — having basic insulation as an element of the protection means for basic protection, and — having supplementary insulation as an element of the protection means for failure protection or — performing basic protection and failure protection by reinforced insulation
Class III equipment	Class III equipment refers the equipment which depends on the voltage limitation called extra-low voltage as an element of the means for basic protection and has no element for failure protection.

The definition in the table shall be as follows.

Basic protection: Protection against electric shock under the normal condition (failure-free condition)

Failure protection: Protection against electric shock under the single fault condition (example: failure of basic insulation)

Basic insulation: Insulation of the hazardous-live parts which provides basic protection against electric shock

Supplementary insulation: Independent insulation in addition to basic insulation in order to perform protection against electric shock (failure protection) at the time of failure of basic insulation

Reinforced insulation: Insulation of the hazardous-live parts which provides a degree of protection against electric shock equivalent to double insulation

Double insulation: Insulation comprising of both basic insulation and supplementary insulation

Extra-low voltage: It means ELV and refers to PELV or SELV.

Annex JE (informative)
Conductor class of for insulated cable

Introduction

This Annex is to describe in order to aid the understanding of this Standard, and not to constitute the provisions of this Standard.

In this Standard, the term "Class" of the conductor is used for specifying the requirements of conductors and cables. The "Class" used in this Standard is based on **JIS C 3644** *Conductors of insulated cables*. This Annex summarizes and explains the meaning of "Class" which **JIS C 3644** specifies.

JE.1 Location of use of "Class" of conductor

The location where this Standard uses the "Class" of the conductor is given in table JE.1.

Table JE.1 Location of use of "Class" of conductor and specified matter

Location of use		Specified matter
12.2	Table 5	Minimum cross-sectional areas of conductors of Class 1, Class 2, Class 5 and Class 6 which this Standard permits are specified (larger than the minimum cross-sectional areas specified in **JIS C 3664**).
	Third paragraph	Class 1 and Class 2 conductors are primarily intended for use between rigid and non-movable parts.
	Fourth paragraph	All conductors that are subject to frequent movement shall have flexible stranding of Class 5 or Class 6.
12.6.1	First paragraph	Flexible cables shall have Class 5 or Class 6 conductors.
	NOTE 1	Class 6 conductors have smaller diameter strands and are more flexible than Class 5 conductors.
Annex D	Table D.4	Overview of specifications and use of Class 1, Class 2, Class 5 and Class 6 conductors is given.

JE.2 Meaning of "Class" of conductor (JIS C 3664)

The nominal cross-sectional areas of conductors used for a single core and a multi core cable, strand composition, conductor resistance, etc. are specified in **JIS C 3664**. The conductors for cables are classified into four Classes according to the specifications of strands. The Class number becomes larger, the flexibility becomes higher.

The meaning of "Class" of each conductor specified in **JIS C 3664** is given in table JE.2.

Table JE.2 Meaning of "Class" of conductor

Class	Specifications	Use
Class 1	• Solid wires • Material is copper and aluminium. • Nominal cross-sectional area is 0.5 mm^2 to 300 mm^2. However, it is 150 mm^2 or under for copper and 1.5 mm^2 or over for aluminium. (Details are given in table 1 of **JIS C 3664**.)	For fixed wiring
Class 2	• Stranded wires • Material is copper and aluminium. • Nominal cross-sectional area is 0.5 mm^2 to 2 000 mm^2. However, it is 4 mm^2 or over for aluminium. • The minimum number of strands which constitutes a conductor is specified. (Details are given in table 2 of **JIS C 3664**.)	
Class 5	• Stranded wires • Material is limited to copper. • Nominal cross-sectional area is 0.5 mm^2 to 630 mm^2. • The maximum diameter of strands which constitutes a conductor is specified. (Details are given in table 3 of **JIS C 3664**.)	For flexible cable/ flexible cord
Class 6	• Stranded wires • Material is limited to copper. • Nominal cross-sectional area is 0.5 mm^2 to 300 mm^2. • The maximum diameter of strands which constitutes a conductor is smaller than that in class 5. (Flexibility is higher.) (Details are given in table 4 of **JIS C 3664**.)	

Annex JF (informative)
Relationship between this Standard and JIS C 60364 series

Introduction

This Annex is to describe in order to aid the understanding of this Standard, and not to constitute the provisions of this Standard.

This Standard is based on the **JIS C 60364** series in the wide range. In this Standard, there are a part which describes the same specification content as that in **JIS C 60364** and a part which specifies only the subclause number quoted to by **JIS C 60364** and does not describe the specification content concretely. For convenience of the user of this Standard, the summary of parts and clauses of **JIS C 60364** which are referred to by this Standard is given.

JF.1 JIS C 60364 series quoted to this Standard

The parts of **JIS C 60364** quoted in this Standard are as follows.

JIS C 60364-1 *Electrical installations of buildings—Part 1: Fundamental principles, assessment of general characteristics, definitions*

JIS C 60364-4-41 *Electrical installations of buildings—Part 4-41: Protection for safety—Protection against electric shock*

JIS C 60364-4-42 *Electrical installations of buildings—Part 4-42: Protection for safety—Protection against thermal effects*

JIS C 60364-4-43 *Electrical installations of buildings—Part 4-43: Protection for safety—Protection against overcurrent*

JIS C 60364-5-52 *Electrical installations of buildings—Part 5-52: Selection and erection of electrical equipment—Wiring systems*

JIS C 60364-5-53 *Electrical installations of buildings—Part 5-53: Selection and erection of electrical equipment—Isolation, switching and control*

JIS C 60364-5-54 *Electrical installations of buildings—Part 5-54: Selection and erection of electrical equipment—Earthing arrangements, protective conductors and protective bonding conductors*

JIS C 60364-6-61 *Electrical installations of buildings—Part 6-61: Verification—Initial verification*

The related parts of **JIS C 60364** quoted in the clauses of this Standard are shown in table JF.1.

Table JF.1 Part of JIS C 60364 quoted in this Standard

Clause in this Standard	Part of **JIS C 60364** that clause in left column quotes
6 Protection against electrical shock	**4-41**
7 Protection of equipment	**4-43** and **5-52**
8 Equipotential bonding	**4-41** and **5-54**
9 Control circuits and control functions	**5-53**
12 Conductors and cables	**4-41** and **5-52**
16 Marking, warning signs and reference designations	**4-42**
18 Verification	**4-41** and **6-61**
Annex A Protection against indirect contact in TN earthing systems	**4-41** and **6-61**
Annex B Enquiry form for electrical equipment of machines	**1**
Annex D Current-carrying capacity and overcurrent protection of conductors and cables in electrical equipment of machines	**5-52**
Annex JA Protection against indirect contact in TT earthing systems	**4-41** and **6-61**

JF.2 Configuration comparison between this Standard and JIS C 60364-4-41 with respect to protection against electric shock

This Standard has many parts which are common to the specification of **JIS C 60364-4-41** especially on the protection against electric shock. The configuration comparison of the specification of protection against electric shock between this Standard and **JIS C 60364-4-41** is shown in figure JF.1.

In figure JF.1, the arrow of a dotted line shows that the same specification content of **JIS C 60364-4-41** (not always all) is described in the subclause concerned of this Standard.

The arrow of a thick continuous line shows that requirements are not described concretely in this Standard and subclauses of **JIS C 60364-4-41** are quoted.

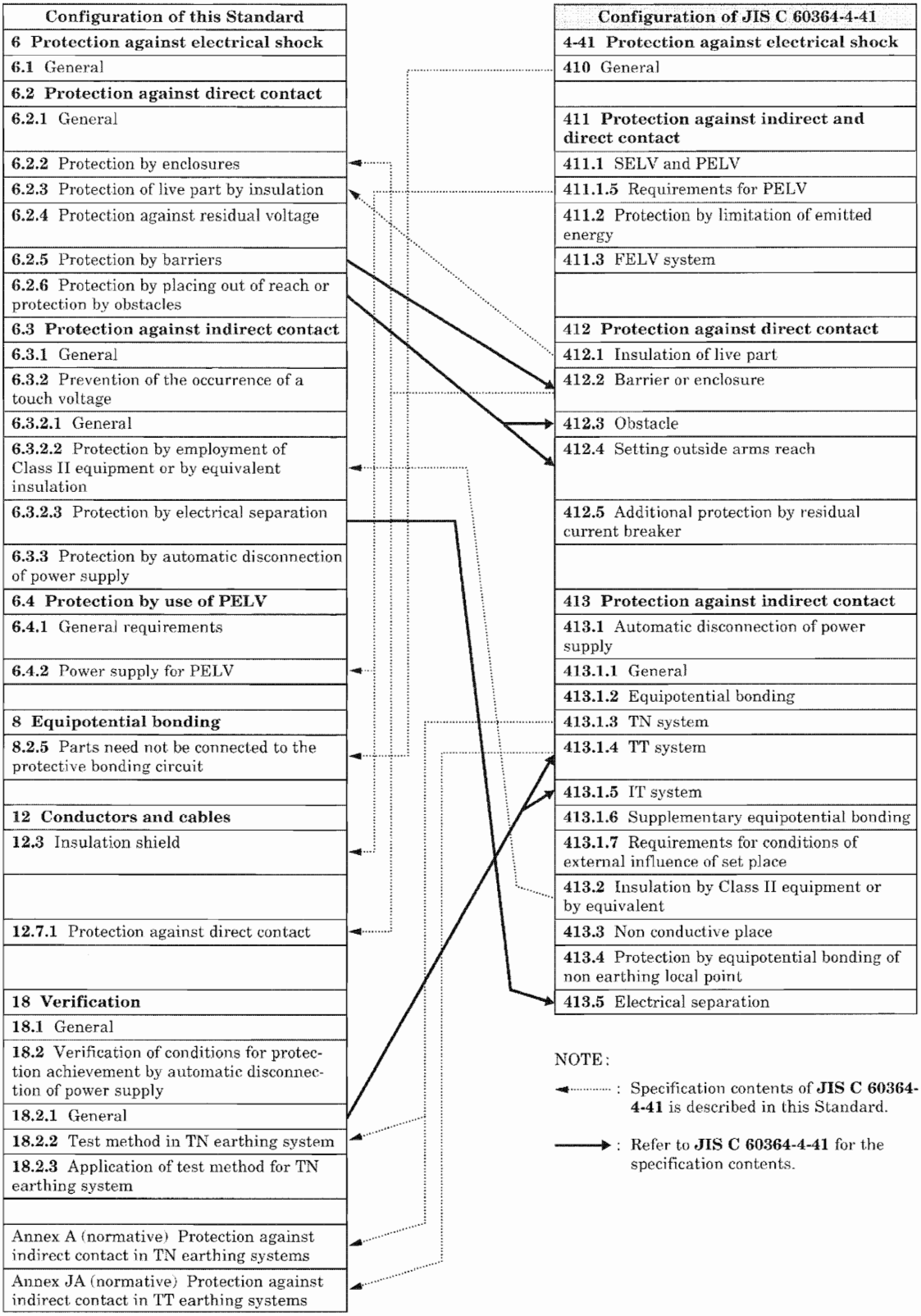


Figure JF.1 Comparison between configurations of protection against electrical shock

Annex JG (informative)
Permissible current of 600 V polyvinyl chloride insulated wires specified in JIS C 3307

Introduction

This Annex is to describe in order to aid the understanding of this Standard, and not to constitute the provisions of this Standard.

JG.1 Permissible current table

The permissible current to the nominal cross-sectional area or the conductor diameter and the installation condition of 600 V polyvinyl chloride insulated wires specified in **JIS C 3307** *600 V Polyvinyl chloride insulated wires* is given in table JG.1. The content of this table is the same as that in table 1 of Annex 4 of **JIS B 6015**.

Table JG.1 Permissible current of 600 V polyvinyl chloride insulated wires specified in JIS C 3307 (at ambient temperature of 40 °C)

Solid wire or stranded wire	Nominal cross-sectional area mm^2	Conductor diameter mm	Exposed wiring	Number of wires accommodated in the same pipe of wiring inside pipe						
				3 max.	4	5 to 6	7 to 15	16 to 40	41 to 60	61 min.
Stranded wire	0.9		14	10	9	8	6	5	5	5
	1.25		15	10	9	9	7	6	5	5
	2.0		22	15	14	12	10	10	9	7
	3.5		30	21	19	17	14	13	11	10
	5.5		40	28	25	22	19	17	15	13
	8		50	34	31	28	24	21	19	17
	14		72	50	45	40	35	31	28	24
	22		94	65	59	52	45	40	36	32
	38		133	92	83	73	64	57	51	45
	60		178	124	111	99	86	76	69	60
	100		244	171	154	137	120	105	95	83
	150		324	225	203	180	157	139	125	109
	200		383	268	241	214	188	165	149	130
	250		456	317	286	254	222	195	177	154
	325		533	371	334	297	259	228	207	180
	400		611	425	383	340	298	261	237	206
	500		690	481	432	384	336	295	268	233
Solid wire		1.0	13	9	8	7	6	5.6	5.3	4.5
		1.2	16	10	10	8	7	6	5	5
		1.6	22	15	14	12	10	10	9	7
		2.0	29	19	18	15	14	12	11	10
		2.6	39	27	24	22	19	17	15	14
		3.2	51	35	31	28	24	22	19	17
		4.0	66	—	—	—	—	—	—	—
		5.0	88	—	—	—	—	—	—	—

NOTE : The number of electric wires accommodated in the same pipe does not include a neutral conductor, an earthing conductor and an electric wire of a control circuit.

Annex JH (informative)
Bibliography

Introduction

This Annex is to describe the bibliography, and not to constitute the provisions of this Standard.

Bibliography

The following table lists the references mainly quoted in NOTE and Annex of this Standard as well as the place in which the references are quoted.

Number of standard and title of standard	Place
JIS B 9702:2000 *Safety of machinery—Principles of risk assessment* (ISO 14121:1999 *Safety of machinery—Principles of risk assessment*)	Annex F
JIS B 9704-1:2006 *Safety of machinery—Electro-sensitive protective equipment—Part 1: General requirements and tests* (IEC 61496-1:2004 *Safety of machinery—Electro-sensitive protective equipment—Part 1: General requirements and tests*)	NOTE 2 of **4.4.2**
JIS B 9710:2006 *Safety of machinery—Interlocking devices associated with guards—Principles for design and selection* (ISO 14119:1998 *Safety of machinery—Interlocking devices associated with guards—Principles for design and selection*)	Annex F
JIS B 9712:2006 *Safety of machinery—Two-hand control devices—Functional aspects and design principles* (ISO 13851:2002 *Safety of machinery—Two-hand control devices—Functional aspects and design principles*)	**9.2.6.2**, **10.6**
JIS B 9713-1:2004 *Safety of machinery—Permanent means of access to machinery—Part 1: Choice of a fixed means of access between two levels* (ISO 14122-1:2001 *Safety of machinery—Permanent means of access to machinery—Part 1: Choice of fixed means of access between two levels*)	NOTE of **11.5**
JIS B 9713-2:2004 *Safety of machinery—Permanent means of access to machinery—Part 2: Working platforms and walkways* (ISO 14122-2:2001 *Safety of machinery—Permanent means of access to machinery—Part 2: Working platforms and walkways*)	NOTE of **11.5**
JIS B 9713-3:2004 *Safety of machinery—Permanent means of access to machinery—Part 3: Stairs, stepladders and guard-rails* (ISO 14122-3:2001 *Safety of machinery—Permanent means of access to machinery—Part 3: Stairs, stepladders and guard-rails*)	NOTE of **11.5**
JIS B 9713-4:2004 *Safety of machinery—Permanent means of access to machinery—Part 4: Fixed ladders* (ISO 14122-4:2004 *Safety of machinery—Permanent means of access to machinery—Part 4: Fixed ladders*)	NOTE of **11.5**
JIS B 9714:2006 *Safety of machinery—Prevention of unexpected start-up* (ISO 14118:2000 *Safety of machinery—Prevention of unexpected start-up*)	NOTE 1 of **5.4**

Number of standard and title of standard	Place
JIS B 9960-11:2004 *Safety of machinery—Electrical equipment of machines—Part 11: Requirements for HV equipment for voltages above 1000V a.c. or 1500V d.c. and not exceeding 36kV* (IEC 60204-11:2000 *Safety of machinery—Electrical equipment of machines—Part 11: Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV*)	NOTE 5 of clause **1**
JIS B 9960-31:2004 *Safety of machinery—Electrical equipment of machines—Part 31: Particular safety and EMC requirements for sewing machines, units and systems* (IEC 60204-31:2001 *Safety of machinery—Electrical equipment of machines—Part 31: Particular safety and EMC requirements for sewing machines, units and systems*)	Clause **1**
JIS B 9960-32:2004 *Safety of machinery—Electrical equipment of machines—Part 32: Requirements for hoisting machines* (IEC 60204-32:1998 *Safety of machinery—Electrical equipment of machines—Part 32: Requirements for hoisting machines*)	Clause **1**
JIS C 3664:2007 *Conductors of insulated cables* (IEC 60228:2004 *Conductors of insulated cables*)	NOTE of table 10
JIS C 3665-1:1998 *Tests on electric cables under fire conditions—Part 1: Test on a single vertical insulated wire or cable* (IEC 60332-1:1993 *Tests on electric cables under fire conditions—Part 1: Test on a single vertical insulated wire or cable*)	**13.3**
JIS C 8201-5-2 *Low-voltage switchgear and controlgear—Part 5: Control circuit devices and switching elements—Section 2: Proximity switches* (IEC 60947-5-2:1997 *Low-voltage switchgear and controlgear—Part 5-2: Control circuit devices and switching elements—Proximity switches*)	NOTE 2 of **4.4.2**
JIS C 60364 series *Electrical installations of buildings* [IEC 60364 (all parts): *Electrical installations of buildings*]	NOTE 4 of clause **1**
JIS C 61000-6-1:2003 *Electromagnetic compatibility (EMC)—Part 6: Generic standards—Section 1: Immunity for residential, commercial and light-industrial environments* (IEC 61000-6-1:1997 *Electromagnetic compatibility (EMC)—Part 6: Generic standards—Section 1: Immunity for residential, commercial and light-industrial environments*)	NOTE 1 of **4.4.2**
JIS C 61000-6-2:2003 *Electromagnetic compatibility (EMC)—Part 6: Generic standards—Section 2: Immunity for industrial environments* [IEC 61000-6-2: 1999 *Electromagnetic compatibility (EMC)—Part 6-2: Generic standards—Immunity for industrial environments*] NOTE: For the corresponding International Standard, **IEC 6100-6-2**:2005 is described.	NOTE 1 of **4.4.2**
IEC 60038:2002 *IEC standard voltages*	NOTE of table A.1
IEC 60269-1:1998 *Low-voltage fuses—Part 1: General requirements*	**D.3**
IEC 60335 (all parts) *Household and similar electrical appliances—Safety*	Annex C
IEC 60757:1983 *Code for designation of colours*	NOTE of **13.2.4**
IEC 60909 (all parts) *Short-circuit currents in three-phase a.c. systems*	**A.2**

Number of standard and title of standard	Place
IEC/TR 61000-5-2:1997 *Electromagnetic compatibility (EMC)—Part 5: Installation and mitigation guidelines—Section 2: Earthing and cabling*	NOTE 2 of **4.4.2**
IEC 61000-6-4:1997 *Electromagnetic compatibility (EMC)—Part 6: Generic standards—Section 4: Emission standard for industrial environments*	NOTE 1 of **4.4.2**
IEC 61180-2:1994 *High-voltage test techniques for low-voltage equipment—Part 2: Test equipment*	**18.4**
IEC/TS 61200-53:1994 *Electrical installation guide—Part 53: Selection and erection of electrical equipment—Switchgear and controlgear*	NOTE of table 10
IEC 61557 (all parts) *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c.—Equipment for testing, measuring or monitoring of protective measures*	**18.1**
IEC 61558-2-17:1997 *Safety of power transformers, power supply units and similar—Part 2: Particular requirements for transformers for switch mode power supplies*	NOTE of **9.1.1**
IEC 61800-3:2004 *Adjustable speed electrical power drive systems—Part 3: EMC requirements and specific test methods*	NOTE 2 of **4.4.2**
IEC 61800-5-1:2003 *Adjustable speed electrical power drive systems—Part 5-1: Safety requirements—Electrical, thermal and energy*	NOTE 2 of **8.2.8**
CISPR 61000-6-3:1996 *Electromagnetic compatibility (EMC)—Part 6: Generic standards—Section 3: Emission standard for residential, commercial and light-industrial environments*	NOTE 1 of **4.4.2**
IEC Guide 106:1996 *Guide for specifying environmental conditions for equipment performance rating*	NOTE of **4.3.3**
CENELEC HD 516 S2 *Guide to use of low-voltage harmonized cables*	NOTE of **12.1**

Annex JI (informative)
Comparison table between JIS and corresponding International Standard

JIS B 9960-1:2008 *Safety of machinery—Electrical equipment of machines—Part 1: General requirements*					**IEC 60204-1**:2005 *Safety of machinery—Electrical equipment of machines—Part 1: General requirements*		
(I) Requirements in **JIS**		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between **JIS** and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		Clause No.	Content	Classification by clause	Detail of technical deviation	
4 General requirements 4.2 Selection of equipment	If there are relevant **JIS**s or **IEC** Standards, the equipment which conforms to them shall be used.		4 4.2	Conform to relevant **IEC** Standards where such exist	Selection	In this Standard, it is accepted to use the **JIS** conforming equipment.	It is appropriate to use the **JIS** conforming equipment in Japan. The **IEC** Standard conforming equipment is not intended to be excluded.
5 Connection of incoming power supply conductors, disconnectors and devices for switching off			5				

(I) Requirements in **JIS**		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between **JIS** and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		Clause No.	Content	Classification by clause	Detail of technical deviation	
5.3.3 Requirements	Fifth item Capable of disconnecting all live conductors of its power supply circuit. However, when the power is supplied in the TN-S earthing system, the neutral conductor may or may not be disconnected. In any earthing system, the PE conductor and the PEN conductor shall not be disconnected.		5.3.3	Fifth item Capable of disconnecting all live conductors of its power supply circuit. However, when the power is supplied in the TN-S supply systems, the neutral conductor may or may not be disconnected except in countries where disconnection of the neutral conductor, when used, is compulsory.	Alteration	Since the TN earthing system is almost not used and it is not required to disconnect the neutral conductors in Japan, this situation is clarified in **JIS**. It is also specified that the protective conductor shall not be disconnected.	Based on the earthing system in Japan.
6 Protection against electric shock 6.3.3 Protection by automatic disconnection of power supply	The permissible breakage times applicable to the TT earthing system in addition to the TN earthing system are additionally specified (in Annex JA).		6 —	Only the maximum disconnecting times for the TN systems are specified (in Annex A).	Addition	In the International Standard, the TT earthing system used as the commercial power supply system in Japan is not specified in detail. In **JIS**, it is specified in detail.	Since internationally it is strongly pointed out that the TT earthing system in Japan is inferior to the TN earthing system which is mainly used in Europe and the United States from the viewpoint of safety, the TT earthing system tends to be treated lightly in terms of safety standards. Through the **IEC**/TC44 activities, the standardization of the TT system will be enhanced in **IEC**.

(I) Requirements in **JIS**		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between **JIS** and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		Clause No.	Content	Classification by clause	Detail of technical deviation	
12 Conductors and cables 12.1 General requirements	Conductors and cables shall be selected so as to be suitable for the use conditions. These requirements do not apply to the integral wiring of assemblies manufactured and tested in accordance with their relevant **JIS**s or **IEC** Standards (for example, **IEC 60439-1**).		12 12.1	Conductors and cables shall be selected so as to be suitable for the use conditions. These requirements do not apply to the integral wiring of assemblies manufactured and tested in accordance with their relevant **IEC** Standards (for example, **IEC 60439-1**).	Selection	In this Standard, it is accepted to use the **JIS** conforming equipment.	It is appropriate to use the **JIS** conforming equipment in Japan. The **IEC** Standard conforming equipment is not intended to be excluded.
15 Accessories and lighting 15.2.4 Mounting instrument	The lampholders shall conform to the relevant **JIS**s or **IEC** Standards.		15 15.2.4	The lampholders shall be in accordance with the relevant **IEC** Standard.	Selection	In this Standard, it is accepted to use the **JIS** conforming equipment.	It is appropriate to use the **JIS** conforming equipment in Japan. The **IEC** Standard conforming equipment is not intended to be excluded.

(I) Requirements in **JIS**		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between **JIS** and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		Clause No.	Content	Classification by clause	Detail of technical deviation	
18 Verification 18.1 General	Where there is no product standard, the general conditions for the verification range of the electrical equipment are specified. The tests shall be performed using measuring equipment in accordance with relevant **JIS**s or **IEC** Standards.		18 18.1	Where there is no product standard, the general conditions for the verification of the electrical equipment are specified. The tests shall be carried out by measuring equipment in accordance with relevant **IEC** Standards.	Selection	In this Standard, it is accepted to use the **JIS** conforming equipment.	It is appropriate to use the **JIS** conforming equipment in Japan. The **IEC** Standard conforming equipment is not intended to be excluded.
18.2 Verification of conditions for protection achievement by automatic disconnection of power supply	The TN earthing system shall be in accordance with **18.2.2**, **18.2.3** and Annex A. The TT earthing system shall be in accordance with Annex JA. For IT earthing system, see **JIS C 60364-6-61**.		18.2	The TN systems shall be verified by tests described in **18.2.2**, **18.2.3** and Annex A. For TT and IT systems, see **IEC 60364-6-61**.	Alteration	Since the power distribution system in Japan is almost the TT earthing system, in order to show the concrete requirements domestically, Annex JA is added to use as the standard.	Based on the power supply system in Japan.
Annex JA (normative)	Protection against indirect contact in TT earthing systems		—	—	Addition	The specification of protection against indirect contact in the TT earthing system used in Japan is summarized as Annex.	Since counties which use the TT earthing system are few except Japan, it is not specified in detail in the International Standard. In order to specify this clearly in **JIS**, Annex JA is added.

Overall degree of correspondence between **JIS** and International Standard (**IEC 60204-1**:2005): MOD

NOTE 1 Symbols in sub-columns of classification by clause in the comparison table indicate as follows:

— Addition: Adds the specification item(s) or content(s) which are not included in International Standard.

— Alteration: Alters the specification content(s) which are included in International Standard.

— Selection: Provides an alternative choice by adding the specification content(s) of equal status, which may be used as an alternative to that given in the original International Standard.

NOTE 2 Symbol in column of overall degree of correspondence between **JIS** and International Standard in the comparison table indicates as follows:

— MOD: Modifies International Standard.

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